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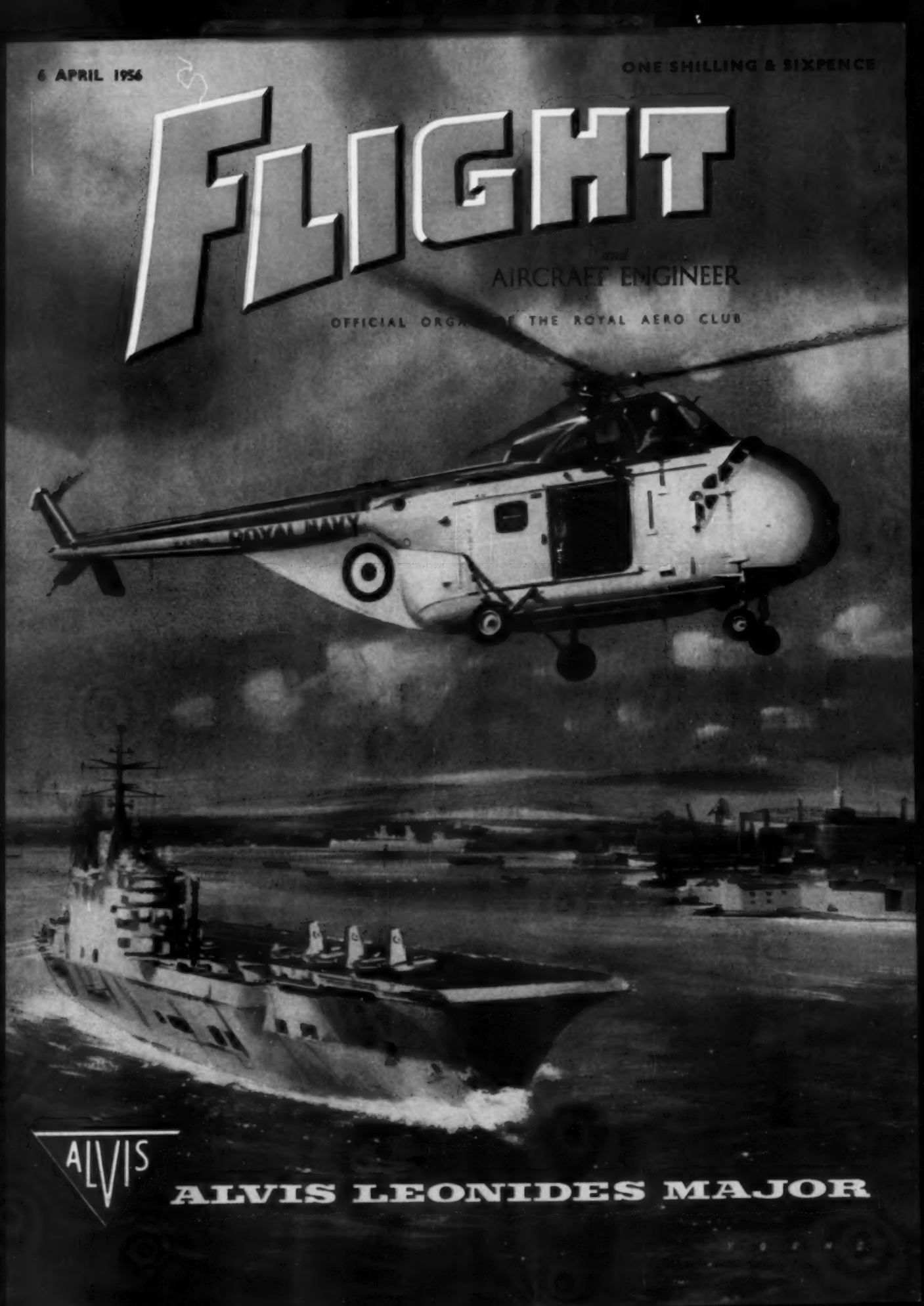

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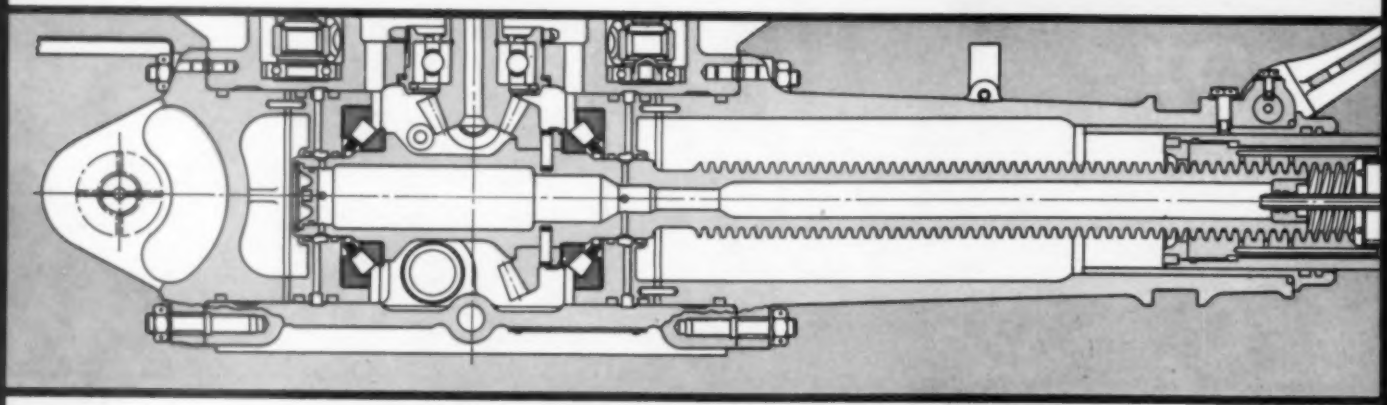

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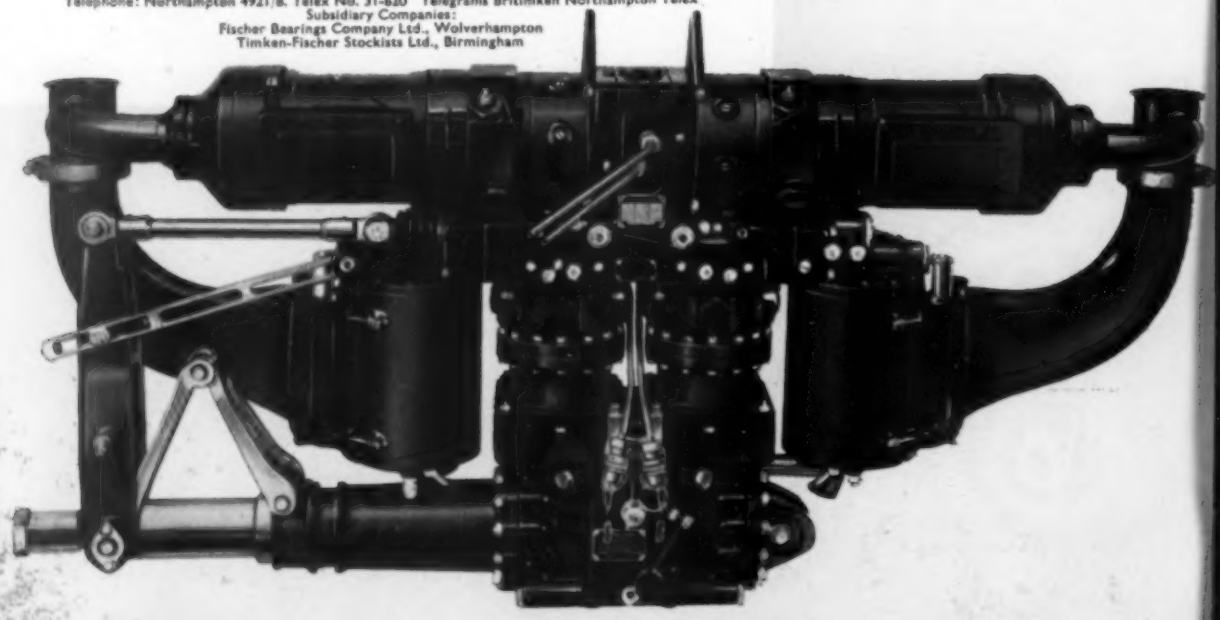

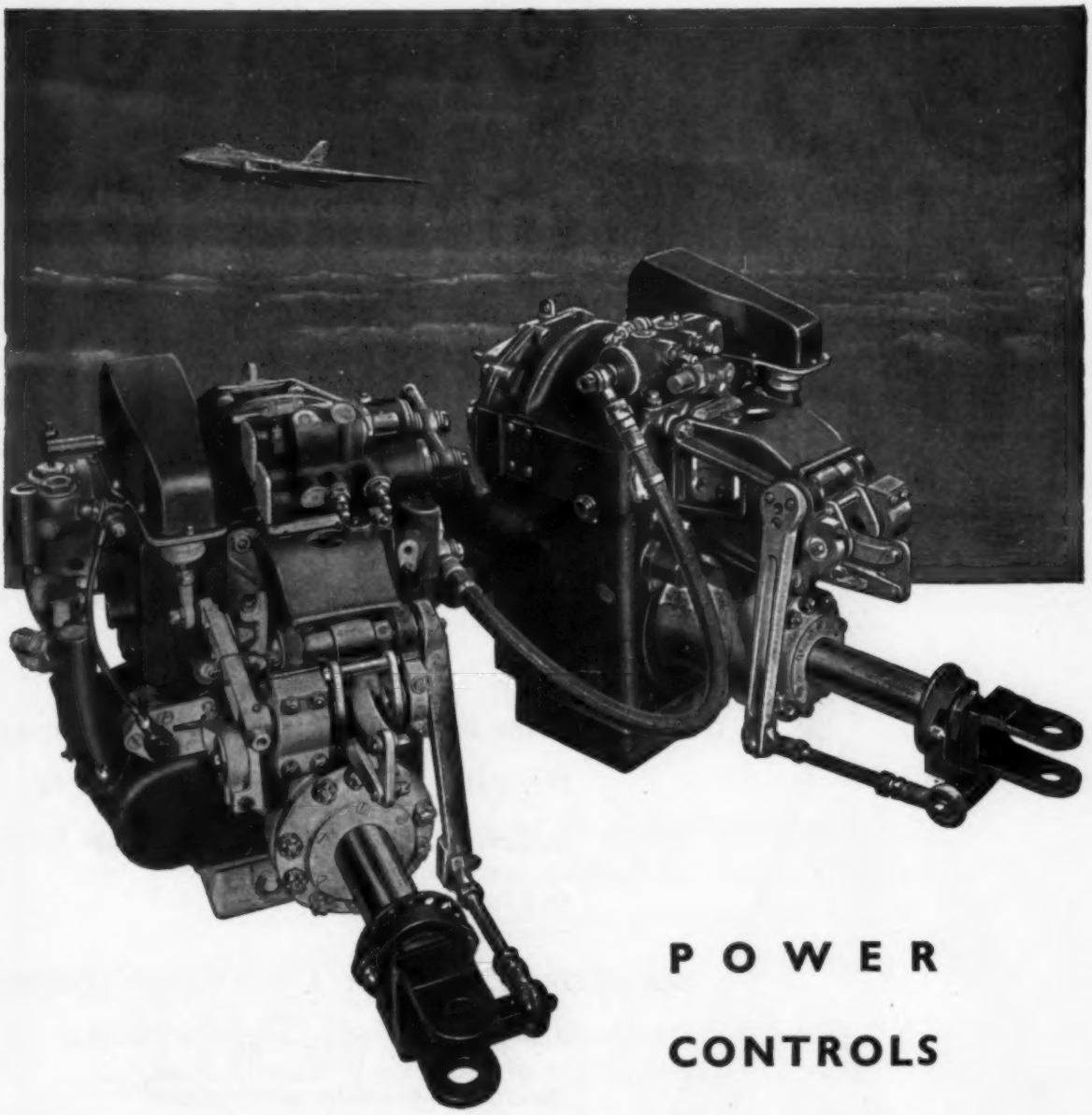

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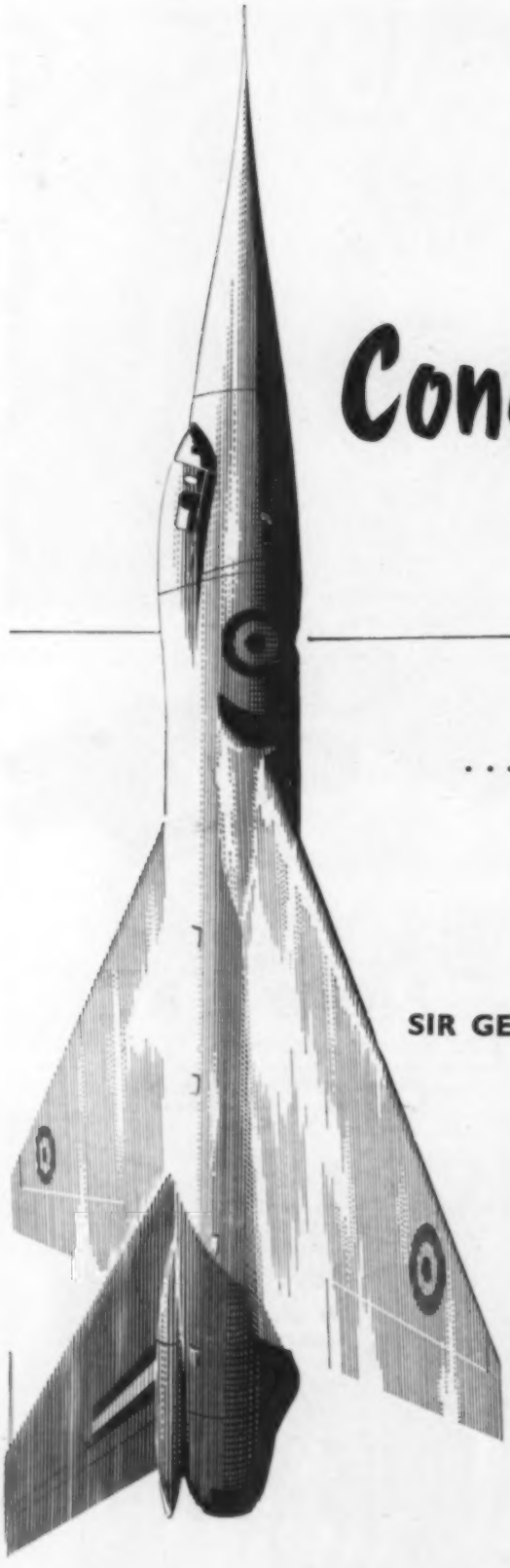

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Left. JET ENGINE FLAME TUBE AND DISCHARGE NOZZLE IN "NIMONIC"

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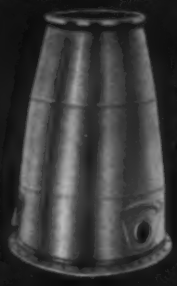

Left. JET ENGINE FLAME TUBE AIR CASING IN MILD STEEL

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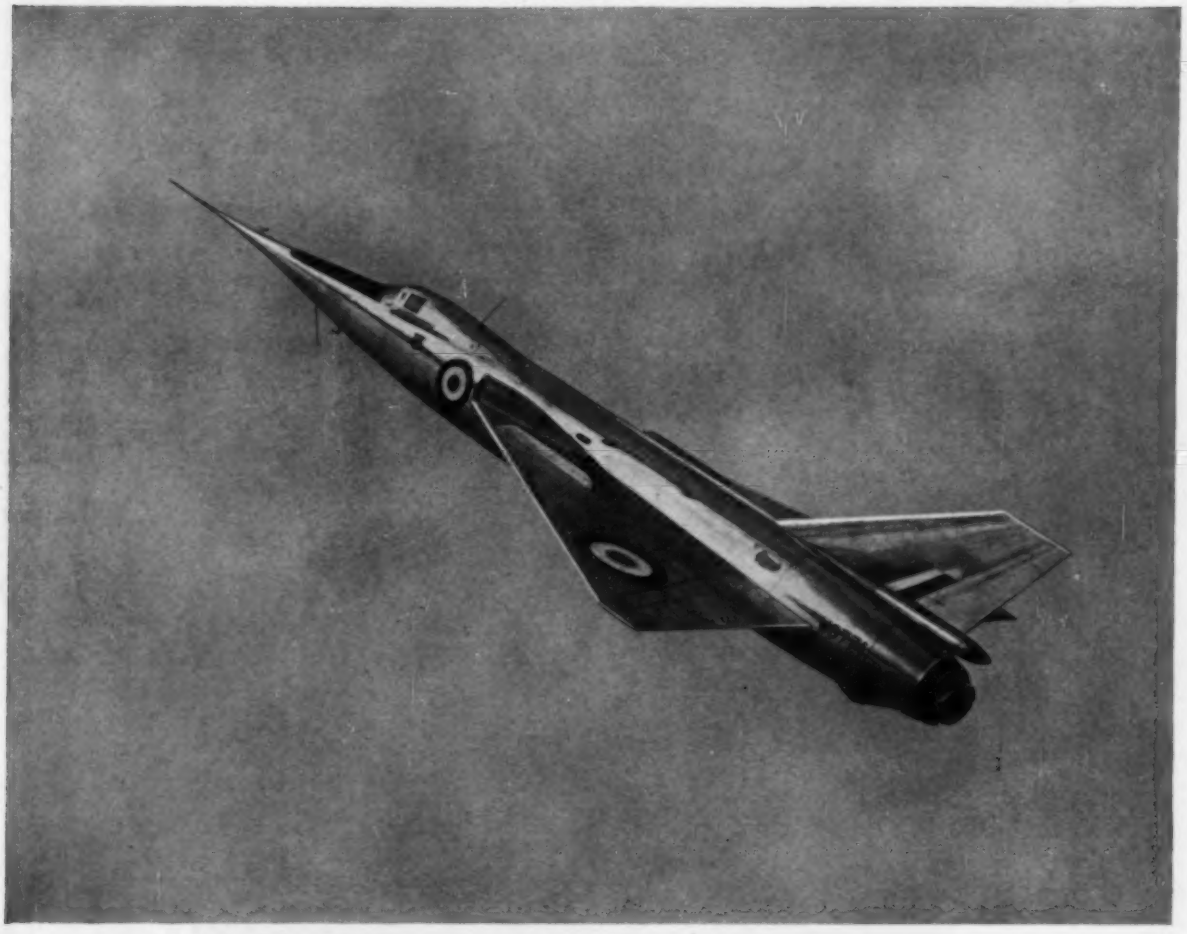

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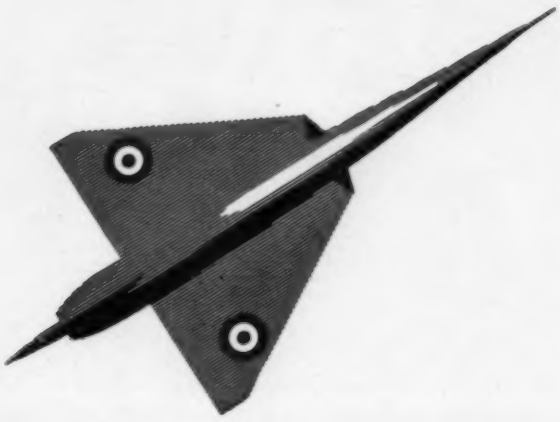

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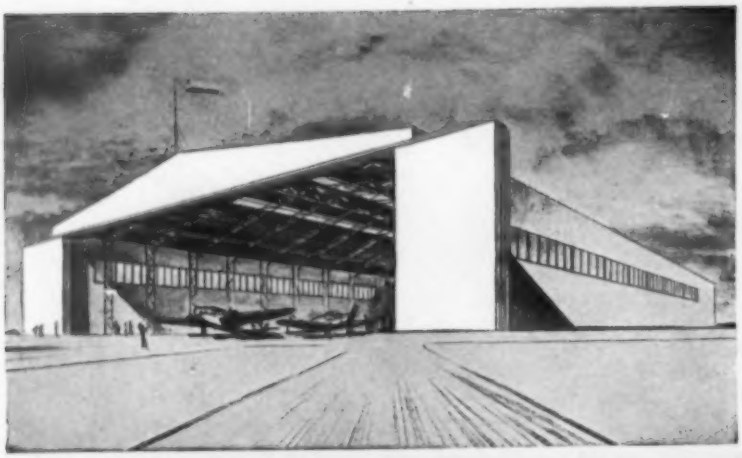

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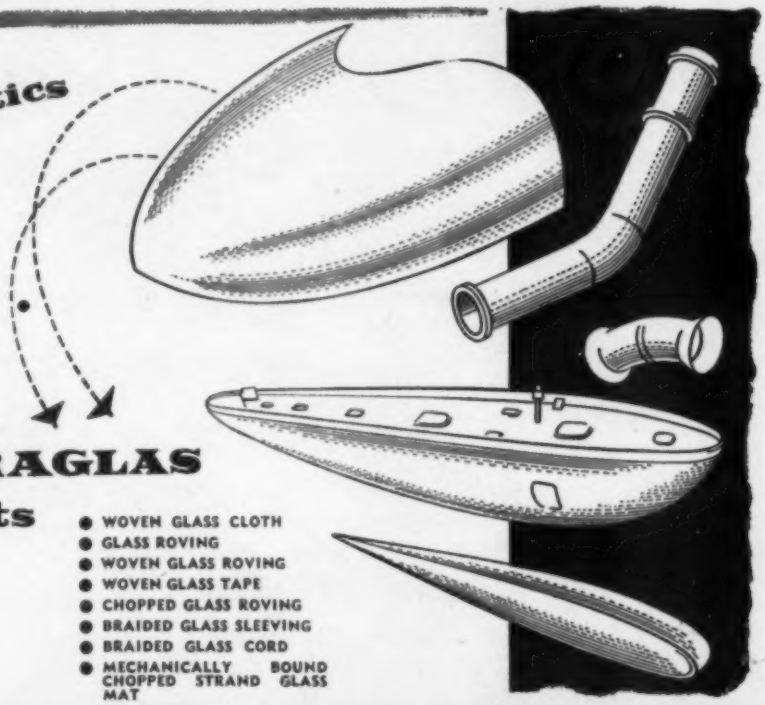

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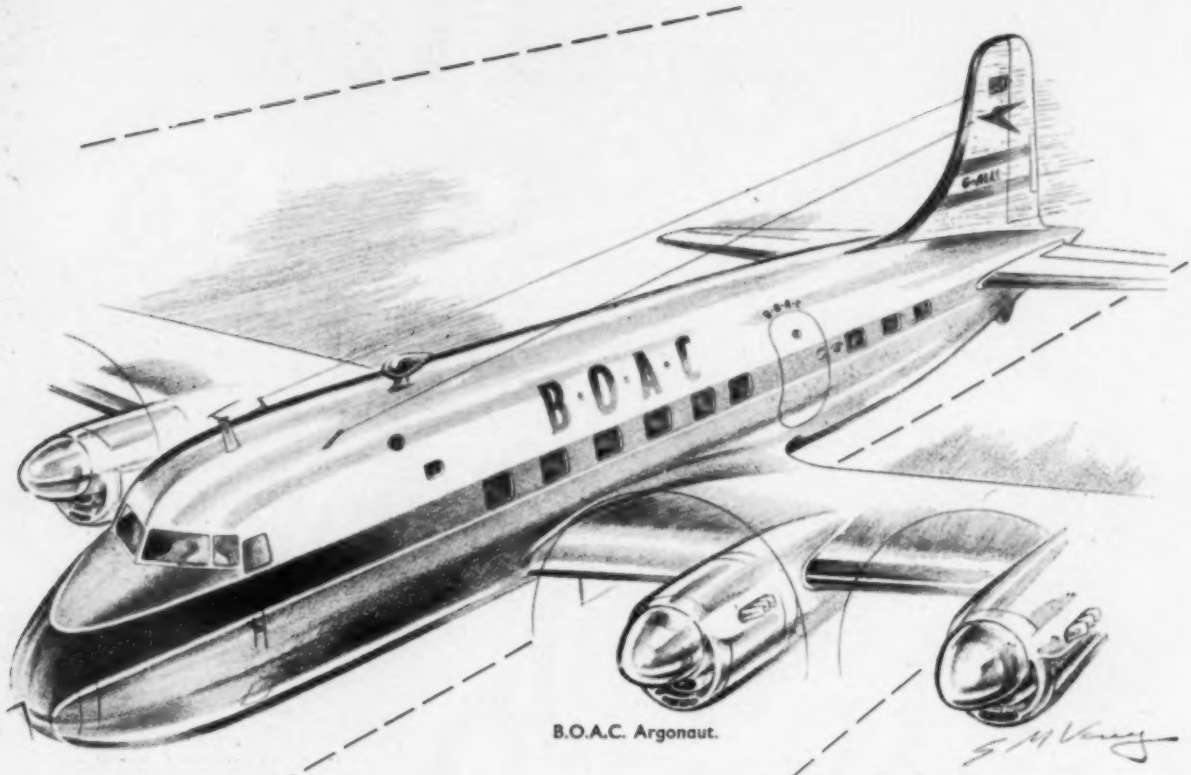

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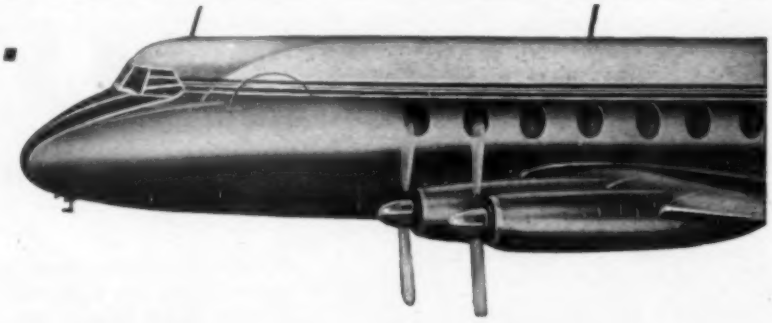

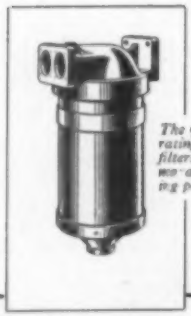

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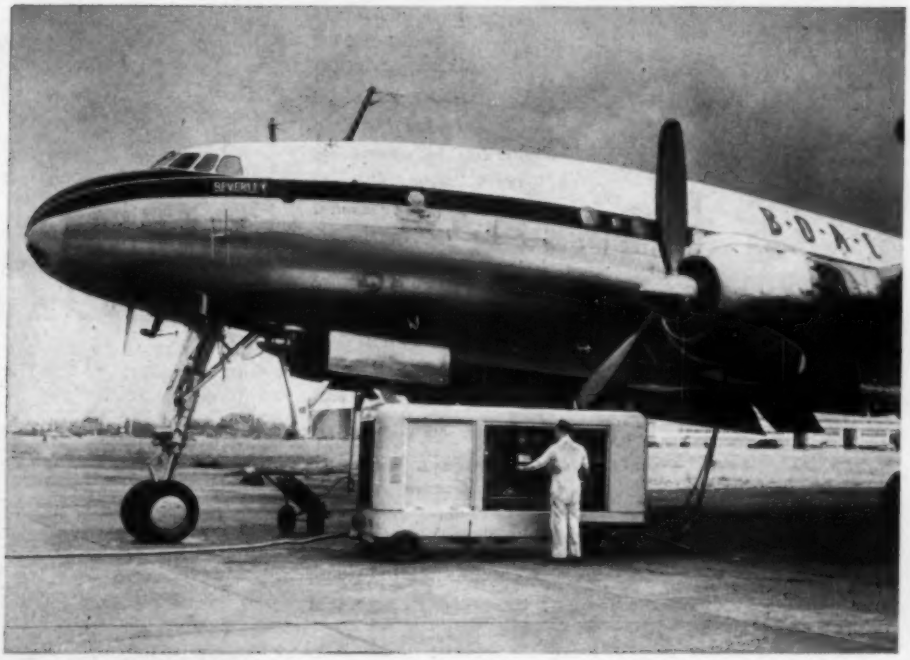

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FLIGHT
and
AIRCRAFT ENGINEER

No 2463 Vol 69 FRIDAY 6 APRIL 1956

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"She Files Beautifully"

WHETHER viewed as showmanship, salesmanship or mere prankishness, the despatch to this country of Russia's Tu-104 jet transport was a *tour de force*. Few aeroplanes have ever created such profundity of interest—or such frothy gossip; and never, one supposes, have "qualified observers" been so capricious in their assessments. "World beater"; "not a very good aeroplane"; "of awkward size"; "about the same size as the Comet"; "would hardly pass muster for its riveting"; "the surface tolerance is good"; "a twin-jet transport"; "a double twin-jet aeroplane"; "the cabin was not pressurized"; "the aircraft is fully pressurized" . . . these were a few of the piping-hot dogmas served up on the national breakfast tables. From which "sometimes conflicting reports" our Minister of Supply drew the conclusion that here was likely to be formidable competition in the near future.

For one so young the Minister's logic was in this instance a trifle infirm, though his view may ultimately be justified, for the Russians appear set on offering their provocative new creation for export or licence-construction. In view of the fact that primitive piston-engined I1-14s (unpressurized counterparts of the Convair series) are only now beginning to leave the satellite lines the latter possibility remains distant.

Evidently the Soviet salesmen recognize a rival in the Caravelle, and this twin-Avon French beauty has lately been the object of ardent attentions on their part. At first interpreted as acquisitive, these appear in the light of events to have been wholly educative.

As for the Comet, we should be doing the Series 4 less than justice if we failed to remark on its probable superiority at least in range and safety, and doubtless in other respects also.

In the present context we are quite unable to resist passing on a pearl of news-agency tape-transmission following the Tu-104's arrival. Ascribed to S/L. Deverill (hailed as the first Englishman to fly in a Russian jet airliner, but evidently long domiciled in the U.S.S.R.) was the observation "She flied beautifully." Deferring, no doubt, to the squadron leader's diplomatic status, the agency hastened to modify this pronouncement to read, "She files beautifully."

On reflection it can be seen that our now-departed visitor was a file indeed—perhaps the most effective ever used on the Iron Curtain; and can there be any surer means of consolidating the goodwill it created than to consider it from now on as a useful tool and a doughty rival?

Our wishful thought, recently expressed in this column, that a Badger might be seen on the starting line for the Johannesburg race next autumn evoked little but banter and cynicism. But it might yet come about, for the Tu-104 (the experts are for once agreed) is nothing more or less than a civil development of the Badger medium bomber.

May we hear from you, Premier Bulganin, designer Tupolev, or "Director of Civil Aviation" Sakharov?

In the Spring . . .

HAVING seen Britain's jet lead, America's jet lead, and Russia's jet lead successively proclaimed in the national dailies, one rubbed one's eyes on the morning after the Handley Page Victor presentation (pages 377-378), for here—once again—was unstinted acknowledgment of a pre-eminent British aeroplane.

Suddenly it was spring again, and anyone could be forgiven if his fancy lightly turned to thoughts of (dare we suggest?) two of the three major heavier-than-air records in Britain's bag; Britain having the world's finest bombers in production; and orders for the British Viscount beyond 300. Thoughts hardly proper, perhaps; indecorous, no doubt; naughtily Chauvinistic. . . .

But how nice; and how (dare we say it?) true.

FROM ALL QUARTERS

Supersonic Bomber Ordered

A PROTOTYPE order for a supersonic bomber for the R.A.F. has been placed by the Ministry of Supply. The prime contractor is not named but, from a statement by Sir Roy Dobson, Avro managing director, it could be inferred that it is his company. (Nevertheless, Vickers-Armstrongs are known to be intensely interested in this field and Sir Frederick Handley Page said last week that his company also was conducting research into supersonic flight.)

Speaking at the Avro apprentice prize-giving ceremony on January 20th, Sir Roy said that the company had recently received a "very important Ministry contract for a new aircraft." He went on "We have an aeroplane, or something else, which will go through the air very fast—and it is going to get very hot . . ."

Receipt for such a contract would place Avro in a very strong position, for, while their production floor will be filled for at least five years with Vulcan production, the development of a bomber of a later generation would keep them occupied for at least another decade in a major aircraft programme which is hardly likely to be affected by any foreseeable event. Avro are certainly one of the few British companies strong enough to attempt such a programme; in particular their research and testing departments are exceptionally well equipped, both in equipment and personnel.

A reference to such a bomber occurred during the Defence Debate in the Commons. The Minister of Supply, Mr. Reginald Maudling, said that after the present V-bombers there would be "the ballistic missile and at least one other bomber . . . one cannot possibly go nap on either the ballistic missile or a large, high-performance bomber; we must continue to have re-insurance."

Meteor Drone

AT the end of March a report from Adelaide, South Australia, stated that a radio-controlled Meteor has now reached the flight-development stage. No details were disclosed.

The Weapons Research Establishment at Salisbury, 13 miles north of Adelaide, has been working for four years on the general problems of control and guidance of pilotless aircraft and much of this has been associated with the indigenous Pika manned prototype and small Jindivik target. Nevertheless, a pilotless Meteor was considered to be a necessity and the first flight took place on March 23rd. Although a pilot was on board, he did not touch the controls at any point during the flight and future flying will be done without a pilot. The primary application of the aircraft will be in the rôle of target for guided missiles.

Royal Aero Club's A.G.M.

AT the annual general meeting of the Royal Aero Club, on March 27th, a motion of no confidence in the club chairman, Mr. S. Kenneth Davies, was defeated by a large majority. The motion arose from the action of the chairman at the recent dinner of the Association of British Aero Clubs, when he walked out after protesting against a reference by Mr. Geoffrey de Freitas to the procedure for obtaining club landing-cards.

In his report for the year 1955, Mr. Davies said that in December the club's membership comprised 1,629 full members, 444 overseas members and 1,963 associate members. A total of 175 aircraft were maintained under the three-year C. of A. scheme, and 63 firms were now approved to undertake this work. After reviewing the club's activities and other aviation events during the year, the chairman spoke of the affiliated organizations.

Referring to the A.B.A.C., Mr. Davies said: "It is with the greatest regret that I have to report that your committee has for a number of years been extremely worried by the differences between the Association of British Aero Clubs and Centres and our Club. . . . References in the annual reports of the A.B.A.C. have not helped in this connection. Not for the first time we are making approaches to see whether the differences can be discussed, understood and put behind us."

After the meeting, Royal Aero Club awards for 1955 were presented by Lord Brabazon, president of the Club. The Britannia Challenge Trophy was awarded to Capt. J. W. Hackett and Mr. P. J. Moneypenny, for their one-day out-and-return flight in a Canberra P.R.7 between London and New York on August 23rd, and Capt. Hackett received in addition the Geoffrey de Havilland Trophy for the New York-to-London speed record of 550.35 m.p.h. achieved on that occasion. A Royal Aero Club Gold Medal was presented to Mr. John Cunningham, "in recognition of his work in connection with British aviation," and a Silver Medal to S/L. J. S. Fifield for his personal courage in testing automatic-ejection equipment at ground level and at 40,000ft.

New M.o.S. Atomics Post

THE Minister of Supply, Mr. Reginald Maudling, has appointed Mr. E. S. Jackson to be Director-General, Atomic Weapons, as from April 1st. This is a new post, established on the conclusion of the term of office of Lt-Gen. Sir Frederick Morgan as Controller of Atomic Weapons.

When the Atomic Energy Authority was set up in January 1954, says the official announcement, the responsibilities of the Ministry of Supply in this field became limited to trials and supply of nuclear weapons for the Services. General Morgan, formerly Controller of Atomic Energy in the Ministry, was then asked to continue to direct this work as Controller of Atomic Weapons, which involved the organization of trials facilities and of the necessary arrangements for meeting the operational requirements of the armed forces.

In the light of the progress made and experience gained in the past two years, adds the Ministry, it has been decided to integrate these responsibilities more closely with the work of the Controllers of Aircraft Munitions and Guided Weapons and to appoint a Director-General for this purpose.

P.9 Flight Trials

MANUFACTURERS' flight trials of the Edgar Percival P.9 agricultural aircraft (270 h.p. Lycoming GO-480-B1B engine) have now been completed. The makers state that tests under all conditions of loading have proved most satisfactory, design performance figures having been reached in all cases—and in some cases exceeded. The trials have shown that a load can be carried of some 200 lb more than originally specified for the "agricultural overload" category. (A full description was published on December 30th.)

Confirmed figures for performance at full normal load (gross weight 3,415 lb; useful load 1,565 lb) are: top speed (take-off power), 146 m.p.h.; top speed (max. continuous power), 142 m.p.h.; cruising speed, 128 m.p.h.; economical cruising speed, 120 m.p.h.; rate of climb, 1,140 ft/min; take-off run (5 m.p.h. headwind) 105 yd. At the design-overload gross weight of 3,675 lb, the above speeds are each reduced by 2 m.p.h., the rate of climb is 990 ft/min and the take-off run is 155 yd. Landing speed (light) is 37 m.p.h.

LONG - TIME SERVICE: John Cunningham, de Havilland chief test pilot (left) was one of 275 D.H. personnel who, having completed 20 years' service, were congratulated by Sir Geoffrey de Havilland and other founders at Hatfield on March 23rd.

SHORT-TIME TRIP: The one-day return Canberra trip from London to New York made last August by Capt. J. W. Hackett (right) and Mr. P. J. Moneypenny resulted in their being awarded the Britannia Trophy. (See third news item above.)

VICTORS FROM RADLETT

Extension of Handley Page Factory Opened

OF all the great names in Britain's aircraft industry none is more renowned than that of Sir Frederick Handley Page. The company which bears his name was founded in 1909 and from 1912 the main production factory has been at Cricklewood, in North-West London. By 1930, however, the expansion of London's built-up area made it clear that a new site would be required and the company accordingly established an aerodrome at Radlett, Hertfordshire, which was opened in that year by Prince George, later Duke of Kent.

Both Cricklewood and Radlett expanded during and after World War 2. Since the ending of Halifax production, the company have built Hermes and Hastings transports and Canberra bombers, most of the manufacturing being done at Cricklewood and assembly and flying being centred on Radlett. Now, however, the company's great effort is devoted to the Victor medium bomber (the Herald is the prime responsibility of Handley Page, Reading) and this vital programme has made necessary further considerable expansion to the facilities available at Radlett.

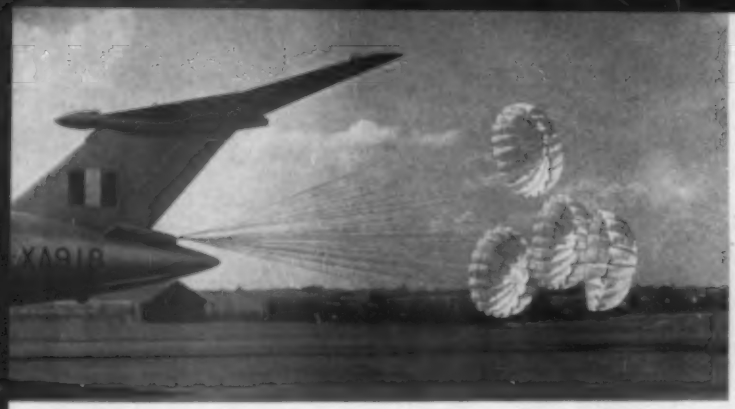
On March 26th the Minister of Supply, Mr. Reginald Maudling, opened a new aircraft-erection hall at Radlett, and the occasion was also the debut of the production Victor (and, incidentally, of the Vampire which has been used for flight-developing the company's boundary-layer control programme, which will be discussed in more detail next week).

There are really two establishments at Radlett. Park Street, at the northern end, is the research, development and experimental-flying centre. The equipment installed there includes a high-speed tunnel driven by three Nene turbojets, and one of the largest—if not the largest—structural-test frames in the country, in which a Victor airframe has undergone a full programme of testing. The Park Street establishment was described and illustrated in our July 31st, 1953, issue. At the southern end of the airfield is the Colney Street establishment, devoted principally to assembly and erection of aircraft, although a low-speed tunnel and the flying-control offices are also situated there.

Handley Page have formulated a major programme, to be

Five production Victor B.1 medium bombers lined up in the new extension to the Handley Page erection hall at Radlett last week. Nearest the camera is XA918 which, as the heading photograph shows, was displayed in flight for our camera.

"Flight" photographs



"Flight" photographs

Above, the new design of tail is apparent as are the triple G.Q. braking parachutes. Above, right, is seen XA918, together with F/L. J. W. Allam, H.P. test pilot; John Barlow, flight observer; and R. W. McKay, inspector-in-charge, A.I.D. On the right the Supply Minister is speaking at the opening ceremony; with him on the platform are Sir Frederick Handley Page; Mr. Christopher Soames, Parliamentary Under-Secretary, Air Ministry; Air Chief Marshal Sir John Baker, Controller of Aircraft M.o.S.; Vice-Admiral W. T. Couchman, Deputy Controller; and A. Cdre. A. V. Harvey, Handley Page deputy chairman.

VICTORS FROM RADLETT . . .

spread over several years, for the transfer of part of the Cricklewood production to Radlett. The first stage is the enlargement of the aircraft-erection hall (described below), together with the building of a large and well-equipped press-shop and new component-assembly and paint shops.

The new erection hall is visible in the lower photograph on page 377. Fitted with doors on all three sides, it is 675 ft long and 31ft high and has an unobstructed width of 150ft. It is divided into five bays which can be isolated by fire-resisting curtains that minimize heat-losses in cold weather when aircraft are being moved through the external doors. Handley Page's contractors have really hustled over these extensions. Erection of steelwork began on September 12th last and, although a railway strike delayed the work by four weeks, the complete framework was finished five weeks ahead of schedule: as a result, nearly half the floor space was made available for production before the end of last year. Despite bad weather the whole building, including heating and lighting services, was completed by March 1st.

At present much of it is given over to Hastings repair and modification, but a considerable amount of the floor-space is already in use for the manufacture and erection of the Victor—supplemented, of course, by the output from Cricklewood. There is no doubt that, by British standards, Handley Page are establishing a formidable production potential which, in Sir Frederick's words, will "satisfy all the critics of the aircraft industry."

Later this year work will start on a new canteen at Colney Street and further additions will be made in 1957. Concurrently, and through the Colney Housing Society, the company is building a large number of houses in the area for its employees (many of whom are being transferred from Cricklewood). The airfield itself has also been considerably improved in recent years; the main runway is now 6,110ft long (plus an 800ft extension), and comprehensive approach-aid, radio and lighting equipment has been installed. A considerable area of hard standings now extend from the new concrete apron outside the erection hall. In fine weather these areas could form valuable extra floor-space.

Of the Victor itself, it is a tribute to the basic rightness of the design that, superficially, the production machine is barely distinguishable from the first prototype. In detail, however, the two aircraft are entirely different. It is now no longer merely a very advanced airframe, but an extraordinarily refined weapons system which will shortly be able to take its place as one of the most potent bombers ever placed in the hands of an air force. Mr. Maudling said last week "so far as we can judge, when the Victor gets into the hands of the R.A.F. it will be the equal in hitting power of any bomber in the world that we know of."

Walking round the machine, the dominant impression is its very modest size, which completely belies its extraordinary all-round combination of range, load and performance. Production machines are powered by four very advanced Armstrong Siddeley Sapphire turbojets (and there is a strong possibility that at least one airframe will be converted to take the Rolls-Royce Conway by-pass engine). Production aircraft are longer than the prototype and have a cleaned-up design of vertical tail with a much smaller root intake and a revised form of "acorn" at the junction of the fin and tailplane. Additional transparent areas have been added in the roof of the flight deck, and subtle changes have also been made to the intakes, the fuselage profile and the wing.

The filling and grinding of all external surfaces, coupled with the employment of sandwich-type construction, makes the Victor an exceptionally "smooth" aircraft. There are many removable panels in the dorsal surface of the fuselage which are no doubt opened to admit the grab of a crane for loading weapons. There is an exceedingly large dielectric area beneath the cockpit floor and a corresponding area in the rear fuselage. Together these presumably serve an advanced radar-bombing system. Stick aerials project from above and below the rear fuselage and a small fixed tailwheel is fitted to act as a bumper. The take-off performance as we saw it last week is nothing short of brilliant, even allowing for the fact that the aircraft was not heavily loaded.

Next year Bomber Command will have received really useful numbers of Victors. There seems little doubt that these aircraft will revitalize the strength of that force and fully live up to the Handley Page tradition of supplying big bombers for the R.A.F.

JOE SMITH—A COLLEAGUE'S MEMOIR

FROM Mr. Alan Clifton, deputy chief designer to the Supermarine Division of Vickers-Armstrongs (Aircraft), Ltd., comes a note of appreciation of Mr. Joseph Smith, C.B.E., former chief designer, who, as recorded last month, died recently at the age of 58. The following are extracts:—

"The close association between Supermarine and Rolls-Royce which existed in Mitchell's time continued under Joe Smith, who greatly admired the drive and energy of Ernest Hives (now Lord Hives) and his team. The Merlin engine development, and later the Griffon, made possible the continued improvement in Spitfire performance. Propeller development, first by de Havillands and afterwards by Rotols, was available to match the increased powers. Frequent meetings were held between the firms at managerial and technical level and the team spirit characteristic of the war period was nowhere more evident. Joe was never satisfied with the rate of progress, although the joint effort of Ernest Hives of Rolls-Royce, Len Fairhurst of Rotols, and Joe Smith was indeed something to remember, and resulted in new marks of Spitfire or Seafire at an average rate of one every three months. The meetings were attended on the Supermarine side by James Bird, who had returned as general manager for the later war period. He and Joe hatched many a plot to surmount any difficulties in the way of getting the new marks to the production stage. Bird and Joe Smith were both fighters, and any opponents to their plans were in for an uncomfortable time. Nevertheless Joe had a remarkable capacity for making friends even of his opponents, and he was quite incapable of bearing a grudge . . .

"The ultimate Spitfire development was given a new name, the Spiteful; and with its Naval counterpart, the Seafang, it represented Joe Smith's last propeller-driven fighter. This aeroplane achieved 494 m.p.h., and there were plans for development which included a two-speed gear for the propeller; there is no doubt it would have comfortably exceeded 500 m.p.h. had the end of hostilities not caused the work to be cancelled."

HEAVY DROPPING

Background to some Original Development Work by the G.Q. Parachute Company

TODAY, April 6th, the Duke of Edinburgh was due to visit the Blackburn and General Aircraft company's factory airfield at Brough, where he was expected to fly the Beverley and to witness heavy supply dropping by the R.A.F.'s massive new freighter. This article, which includes a first-hand account of a recent trial drop from a Beverley, is thus of particularly topical interest.

THE dropping area was 250 acres of pastureland belonging to the farm at Arras, about ten miles from the Blackburn factory at Brough. The sound of a Beverley, I was told, is by now familiar to the sheepdogs, who well know the form should there be sheep too near the area. There was none about today, however: just a small knot of figures, discreetly withdrawn from the large white T which was our dropping reference-mark. A smoke flare indicated wind-direction. As we banked towards the T for a dummy run I clambered down the ten-rung ladder from the flight deck into the hold (which I always think is rather like descending from the hayloft of a capacious barn) to witness the departure of our load—7,000 lb of ballast secured to a platform resting on the rollers of the Beverley's floor. Two 66-ft G.Q. parachutes, packed on top, were robustly harnessed to the platform. The doors of the barn were off, and the green East Riding countryside, as if on a cinema screen, panned past the great square opening as we turned in on the dummy run.

The aimer motioned me to squat beside him at the window in the nose. I plugged in my intercom and watched the T, twelve hundred feet below, approaching at a steady 130 kt. As it came within the crossed wires on the window the aimer, transmitting to the cine-camera crew on the ground, called up: "Five, four, three, two, one—release!"; and, even though this was a dummy run, my fingers instinctively tightened their hold as the switch was thrown. As we banked away to make our run-in for the actual drop, the aimer went aft to release the safety cables, and I took the opportunity of selecting a firm hand-hold.

We were coming over the T again: "Dropping . . . five, four, three, two, one. . . ." The switch was pressed and, holding on hard, I turned to watch the departure of our load. For a long moment nothing happened: then the 14-ft extractor parachute deployed, the laden platform moved slowly towards the opening . . . and vanished. The Beverley gave not the slightest tremor, and I reflected respectfully on the massive stolidity of an aircraft which is unconcerned by the sudden loss of a three-ton load. My respect deepened when I subsequently learnt that 20,000 lb has been dropped with scarcely any effect on trim.

Our particular test, however, was concerned not with the "dropping ability" of the Beverley, which is proved, but with the development of heavy parachute systems in collaboration with the G.Q. Parachute Company. The aircraft used is usually the veteran, work-worn prototype, now seven years old, which although unrepresentative of production Beverleys is quite suitable for parachute development. The limiting factor in supply-dropping is not, of course, aircraft size: the Beverley could drop 50,000 lb if there were a suitable parachute system to take it. The aircraft has, as related, already disgorged 20,000 lb successfully—probably one of the heaviest drops ever made anywhere—and the G.Q. company is working with Blackburn on systems which are expected to exceed this figure handsomely.

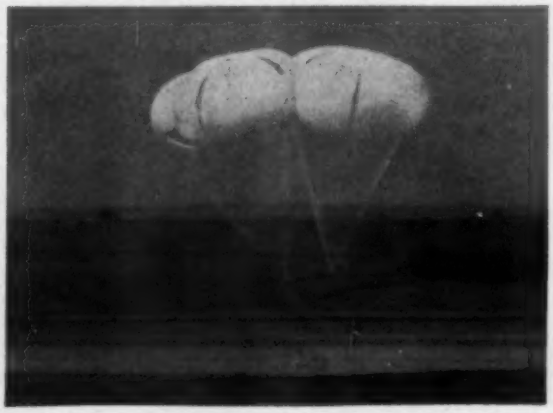
The technical problems involved in the successful delivery of such loads are formidable. No single canopy yet designed can drop weights of more than about 4,500 lb at any acceptable rate of descent (say about 15 m.p.h.) and for heavier drops clusters are employed. It can be appreciated that as the number of canopies per cluster increases, so in proportion do the problems of platform design, extraction, simultaneous deployment, rigging suspension, and recovery.

Until the G.Q. company designed their 66ft "sectional" parachute three years ago, the largest weight that could be parachuted by the Airborne Force was 8,000 lb, this load being handled by a cluster of eight 42-ft canopies. A requirement to drop 24,000 lb, at flight speeds of up to 130 kt, was called for, and the specification to which G.Q. worked demanded that individual parachutes should be capable of handling 3,000 lb at descent speeds of 15 m.p.h. (plus or minus), and that they should, in view of the 24,000 lb requirement, be usable in clusters of eight. At that time American airborne forces were using a 100ft "flat canopy" which was capable of taking 3,500 lb; this parachute, which was used in clusters of up to six, was incidentally almost identical to the type developed in 1942 in this country for dropping boats. It was believed to have suffered from instability, and since it was of one-piece construction it was difficult to repair.

G.Q., starting from first principles, evolved a 66-ft canopy of "shaped" design, and it has been shown to work extremely well. A high drag-coefficient—considerably higher than that of the old flat hundred-footer—was achieved by deep shaping, and stability was found to be of a remarkably high order when each segment was left unlaced (a difficult process in any case); the four great slits are a prominent feature of the canopy. Weight was kept to about 250 lb, i.e. considerably less than ten per cent of the "payload", which was the requirement, and even this will probably be further reduced in time. Drops have been made at 150 kt, 20 kt faster than was called for, and a cluster of four has been released from a height of 950ft successfully enough to suggest that drops from 800ft would be safe. A satisfactory 4,550-lb single-canopy drop has been achieved, representing a 50 per cent overload. The largest cluster dropped to date (the 20,000-lb load previously mentioned) consisted of six canopies, and tests working up to the required cluster-of-eight, using the impeturbable Beverley, are continuing.

J.M.R.

Extraction and deployment: the pictures above and below, taken from a ciné film, show a cluster of four 66ft G.Q. parachutes (note the stability slits) delivering a comparatively small load of 12,000 lb. The aircraft used for the heavy dropping trials—discussed in the text—is the prototype Blackburn Beverley.



"Flight" photograph

FAST AND LOW at Woodley, the Somers-Kendall S.K.1, powered by one Turboméca Palas turbojet, is being groomed for its racing debut this season. Designed—and here flown—by Hugh Kendall, the clean new racer features a vee tail and full-span ailerons.

HERE AND THERE

Canberras for I.A.F.

A DECISION "in principle" to equip the Indian Air Force with English Electric Canberras was announced in Delhi last week-end. The aircraft are believed to have been chosen in preference to Russian Il-28s.

Aer Lingus Orders Friendships

AS we forecast three weeks ago, Aer Lingus has ordered Fokker Friendships to replace its DC-3s. Deliveries are for late 1958 and early 1959.

Repeat Order

ONE of Japan's largest industrial electricity undertakings has ordered a Westland Dragonfly helicopter. It has already been using a Dragonfly, since 1952, for power-line inspection.

Cranes Jib

A RECENT Notice to Airmen issued by the Canadian Transport Department warns pilots to keep above 2,000ft over the Wood Buffalo National Park in the Northwest Territories. It seems that a rare bird, the fast-vanishing whooping crane, has been seriously disturbed by low-flying aircraft.

Sea-god

A MARINE version of the Proteus turbo-prop is being developed by Bristol Aero-Engines, Ltd., in collaboration with the Admiralty, to power high-speed patrol boats. A test engine, running on Admiralty gas oil, has already completed over 500 hours, a period which has included salt water spray tests. Weighing 3,000 lb, the marine Proteus develops 3,500 s.h.p.

West Germans in U.S.A.

A LARGE group—first of several to come—of West German Air Force groundcrew trainees arrived in the U.S.A. recently for a period of training in air traffic control. They were led by a well-known ex-fighter pilot, Capt. Dietrich Ortmann.

Cranfield Successes

FOUR students at present in the second year of their courses at the College of Aeronautics have been awarded King George VI Memorial Fellowships offered by the English Speaking Union. Three of the students are specializing in aircraft economics and production and one in aircraft design. The Fellowships provide them with opportunities for post-graduate study in the U.S.A. The four successful students are: D. P. Hunt, G. E. Smith, J. B. Tabernacle and J. Thwaite.

Delayed Action ?

"SUPERSONIC bangs were heard yesterday in the Bognor Regis area, where three weeks ago a Fairey Delta aircraft set up a new world air speed record."—*Daily Telegraph.*

Helmet to Mitre

THE new Bishop of Durham, the Rt. Rev. Maurice Harland, served as a fighter pilot in the R.F.C. during the First World War.

Flygmotor Board Changes

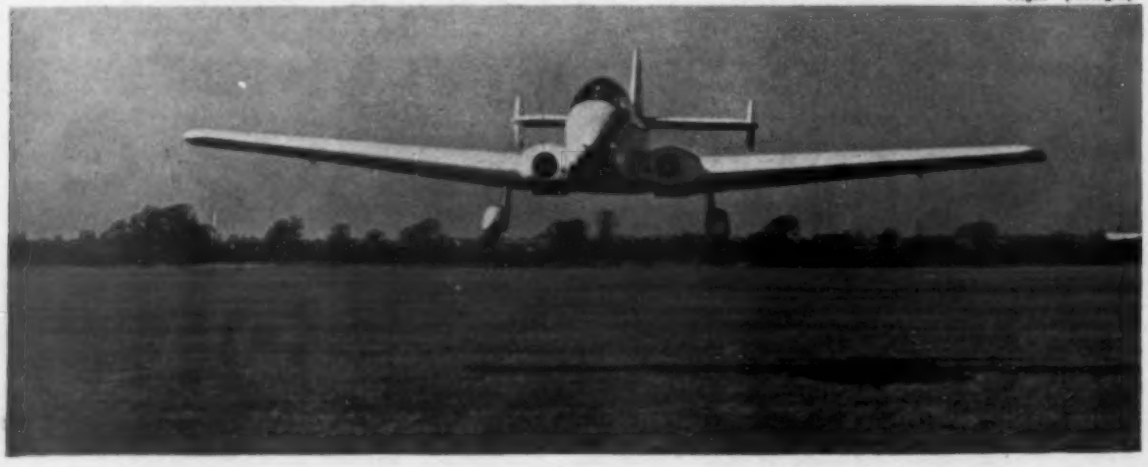
GUNNAR ENGELLAU, managing director of Svenska Flygmotor, the Swedish engine manufacturers, has left his post in order to become managing director of AB. Volvo, Gothenburg, Flygmotor's largest shareholders; he will remain on the Flygmotor Board. Erland Forslund, present deputy managing director, succeeds him.

Sycamore Century

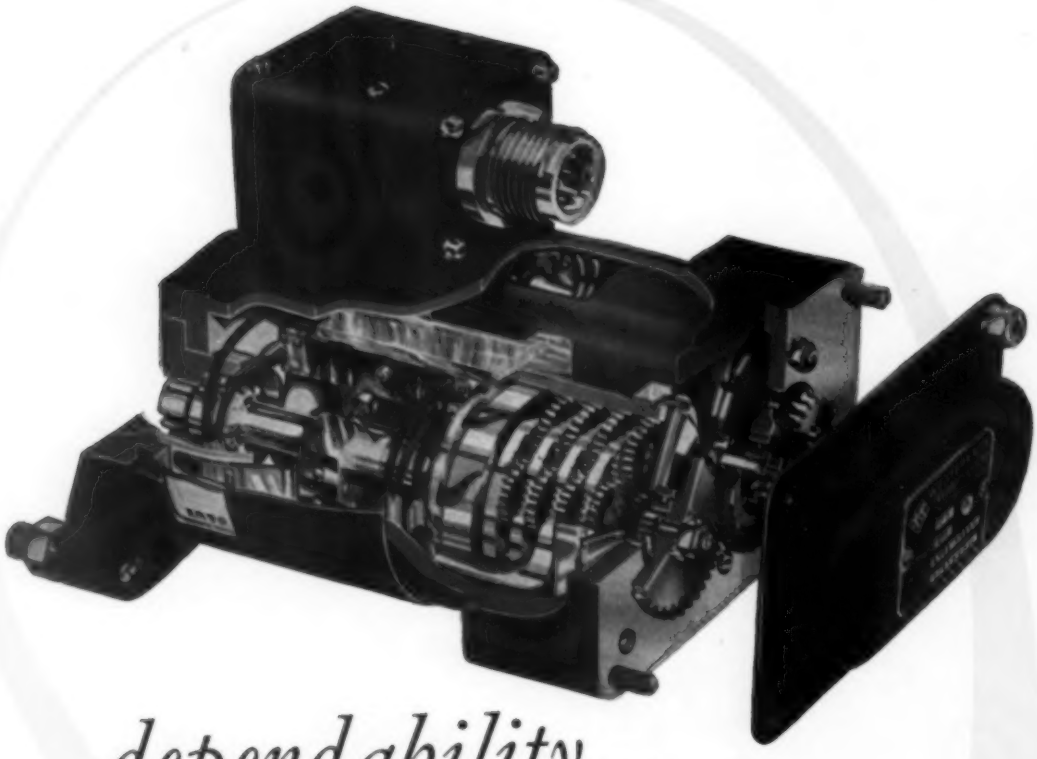
THE manufacturers recently announced that nearly 100 Bristol Sycamore helicopters have been built and delivered. Aircraft of this type have logged about 20,000 hours in a dozen different countries of widely varying climate. The overhaul period for the Alvis Leonides engine and transmission, at present 400 hours, may soon be substantially increased.

LOW AND FAST at Shoreham, the Miles Sparrowjet (two Palas turbojets) is also a most likely contender in this year's National Air Races. Here flown by Ian Forbes of F. G. Miles, Ltd., the Sparrowjet is owned and raced by Fred Dunkerley.

"Flight" photograph



VICKERS
VISCOUNT
FOUR ROLLS-ROYCE DART PROPELLER-TURBINE ENGINES



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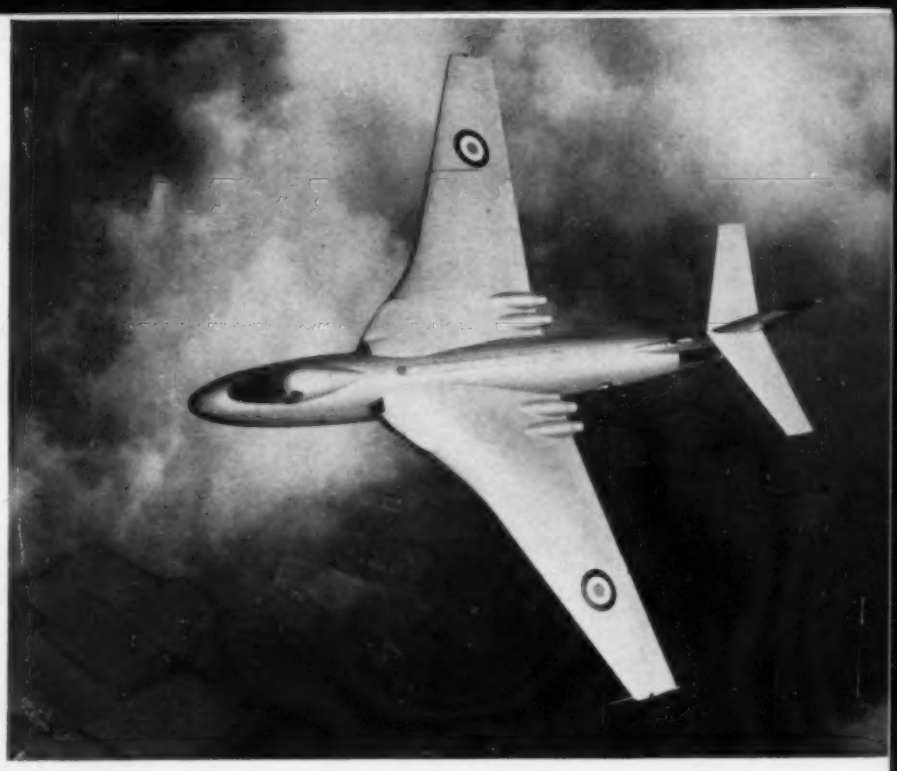
TRAINING for VALIANTS

No. 232 O.C.U. at Gaydon



Impressive from all angles, the Valiant is especially handsome in plan form, as this new picture shows.

THE coming of the Valiant marks the introduction of far more than just another airframe into service with the R.A.F. This four-Avon bomber is the first type for the new V-force, now being built up into an élite force not only in the R.A.F. but in the whole world.

There is at the moment only one equivalent to the V-force (unless the Russians have already formed such an organization) and that is the U.S.A.F.'s Strategic Air Command; but it should not be supposed that the V-force is being copied word for word and gimmick for gimmick from the American organization. The importance of the V-bomber, both as the carrier of frighteningly massive retaliation and as a national capital investment, cannot be over-estimated.

But it is true that the larger the size and the higher the performance of a modern aircraft the more complex it becomes; the more complex it is, the more must the crew know about it; the more that must be known and understood the more does the element of human fallibility become potentially dangerous. Training for V-bomber operations, therefore, is based on the theory that no aircraft must ever be lost, in peace or war, through human failing or pilot error.

Complexity in the case of the Valiant means not necessarily complication, but diversity of equipment and systems, each of which has a specific purpose and usefulness and each of which must be used to best advantage. To do this the crew must have great experience and ability before they ever start flying the aircraft; and then they must learn thoroughly all there is to know about it.

The task of giving initial training to teach crews to handle the Valiant is the task of No. 232 O.C.U. at Gaydon, Warwickshire. Operational training is thereafter completed with the squadrons. It should be emphasized that Valiant crews are already highly trained (see our leading article last week), and their job at Gaydon is to learn about the aircraft.

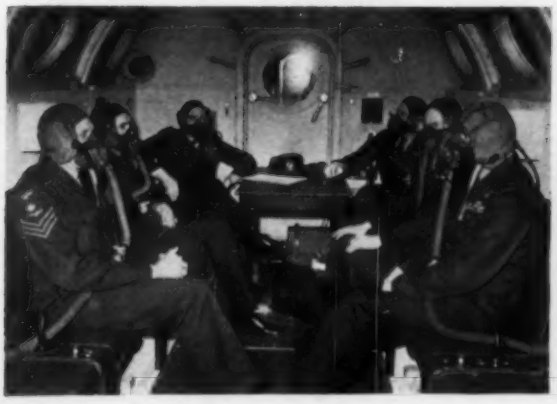
Crews are made up at the O.C.U. from two pilots, one of whom is rated as aircraft commander; two navigators—one a plotter and the other a radar bomb-aimer; and a signaller. The flight-engineer work is done by the co-pilot, who monitors the engines and manages the fuel system.

Training starts with two-and-a-half weeks of ground school on systems and flight planning, followed by a further three weeks in which work in the simulator starts for the pilots. They also make several flights in Canberra T.4s equipped with I.L.S., as it is cheaper to use these smaller aircraft for training in the use of this equipment. By the end of the three months' course the pilots have some 22.5 hours on the simulator and the whole crew have some 50 hours in Valiants, half of these with instructors on board and half at night.

I.L.S. has been adopted by the R.A.F. as a standard approach aid and the Valiant is fitted with a Smiths autopilot with an approach coupler allowing automatic approaches down to 200ft and even lower. Power settings must be controlled by the pilot and there is no flare-out adapter. It seems likely that the same autopilot can be tied-in with some navigation systems.

The Valiant is big, having a length of 108ft 3in and a span of 114ft 4in, and the fin towers 32ft 2in above the ground. Undercarriage, flaps, air-brakes, bomb doors, tailplane incidence, trim, fuel pumps and the flying control hydraulic pumps are all electrically operated. There are 38 miles of wiring, 85 electric motors and actuators and 225 electrical relays of 49 different types. Controls are fully powered, with manual reversion. Arti-

In the training of Valiant crews nothing is left to chance. Personnel are seen undergoing pressure chamber drill (left) and (right) embarking for a training flight after completing the long check-lists. Ground crews stand by to assist with engine starting. "Flight" photographs



"Flight" photographs

Key personnel of No. 232 O.C.U. (above, from the right) are G/C. B. P. Young, Station Commander, W/C. D. Iveson, Chief Instructor, W/C. B. Deaves, Chief Ground Instructor, W/C. T. S. Towell, O.C. Admin. Wing, and W/C. R. T. Morison, Chief Technical Officer. Eight of the O.C.U.'s Valiants lined up at right, are still a rare sight.

TRAINING FOR VALIANTS . . .

ficial feel is provided by a mechanism in the tail, using dynamic pressure sensed from an intake at the root of the fin. Pressurization charge air is tapped from all four engines, and two settings are available, one for normal flight and the other—rather lower—for operational situations. An emergency system will give greatly increased flow to maintain some pressurization despite a puncture of the cabin wall. Before the pilot finally reaches his seat 70 items outside and 40 inside the aircraft have to be checked. Sixty items on the panel are checked before the engines are started. The four Rolls-Royce Avons are started with the aid of a large generator trolley which can also supply power for servicing work. There is a connection in the fuselage side for supply of conditioned air from external sources on the ground.

A great deal of ground equipment is required for servicing, particularly large ladders and gantries for reaching the high tail. Servicing crews are led by a crew chief trained at the Vickers factory, and second-line servicing is carried out by personnel divided into inspection and rectification teams. Teams would handle one aircraft at a time, and their number would be regulated according to the number of aircraft on the particular station.

The most costly and complex piece of training equipment at Gaydon is the flight simulator made by Redifon, Ltd. It is entirely electronic and contains some 3,000 valves. The cockpit section of a Valiant is faithfully reproduced to house two pilots and the supervisor and operator in the navigating compartment behind them. Everything is realistically simulated, including sounds such as that of the engines and of the tyres at touch-down. The simulator is mounted on a fixed base and does not simulate g. Though the cost is high, an hour of operation costs only one tenth of a Valiant flying hour, and emergencies dangerous to reproduce in the air can be simulated in safety.

When the other V-bombers come into service similar schools will be set up to train their crews.

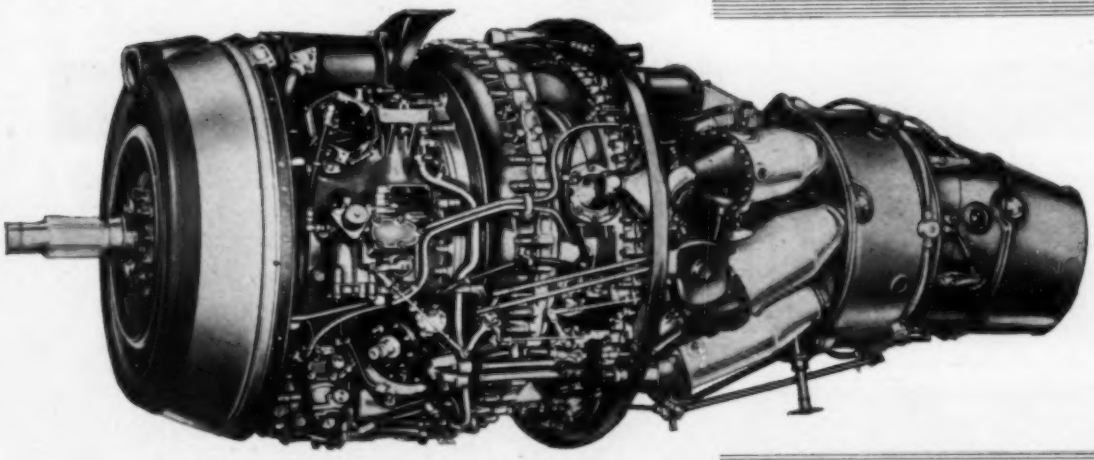
Much servicing equipment has been specially designed for the Valiant. At left is the Safety Raiser, a hydraulically raised platform with protective railings, made by Access Equipment, Ltd., for undercarriage and underwing inspection. At right is some more of the equipment, including pressure-refuelling bowsers, Douglas Tugmaster tractor, with special tow-bar, and a gantry for access to and lifting of tail sections.

"Flight" photographs

THE

ROLLS-ROYCE DART

PROPELLER TURBINE



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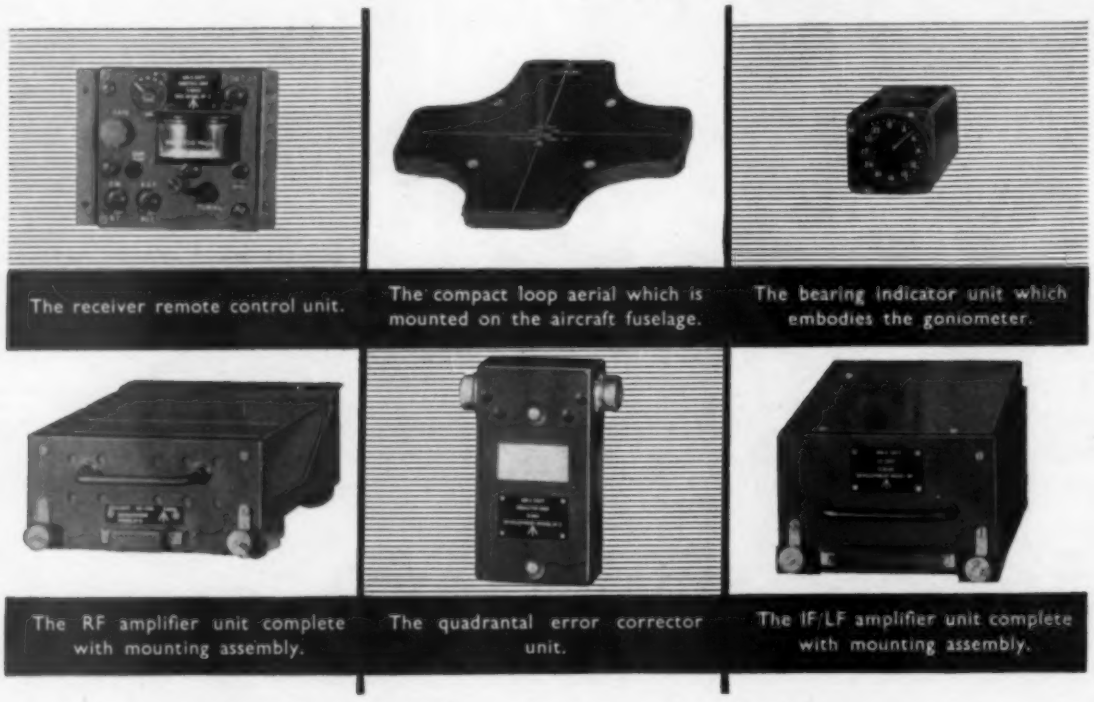

The receiver remote control unit. | The compact loop aerial which is mounted on the aircraft fuselage. | The bearing indicator unit which embodies the goniometer.

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RECORD-BREAKER AT HOME

"Flight" photographs

FROM Boscombe Down, home of the Aeroplane and Armament Experimental Establishment, the Fairey F.D.2 took off on March 10th for its world-record flight at 1,132 m.p.h.—as recorded in *Flight* of March 16th and March 23rd; and from the same base this delta-wing research machine had been working up since its first flight on October 7th, 1954 (except for a period of inactivity following a brilliantly executed emergency landing by the new record-holder Peter Twiss). By courtesy of Boscombe's Air Officer Commanding (A. Cdre. R. A. Ramsay Rae) a *Flight* photographer was allowed to visit the F.D.2 shortly after its world-acclaimed success; and of his pictures the one above emphasizes, more than most yet published, the sharpness and slenderness which characterize the design. Note, particularly, the lozenge-like main wheels, specially developed to retract into the F.D.2's wing—a structure which might be described, by the same token, as wafer-thin. The close-up on the left shows the adjustable "eyelid" tailpipe for the reheated Rolls-Royce Avon turbojet of undisclosed thrust (but certainly delivering a sea-level maximum output well into five figures). This picture includes also the housing for the braking parachute. Next is a main-undercarriage detail, featuring one of the high-pressure Dunlop tyres (28 × 5.25-18). The brakes are of two-piston disc type, with Maxaret. Last is the main hydraulically hinged forward fuselage section and port wing root, showing the sharp-edged intake.

DEVELOPMENTS IN DECCA

Recent Progress Described in Lectures at the Institute of Navigation

LAST week we briefly summarized three papers given in London on March 21st under the auspices of the Institute of Navigation. The general heading of the Symposium was *Developments of the Decca Navigator System*, and the first paper, *Experiences with Decca on Viscount Operations in Europe*, by Capt. E. R. Wright, a senior pilot of B.E.A.'s Viscount Flight, dealt with the practical handling of the system. The lecturer took his audience on a European flight from London Airport with the aid of actual Flight Log chart illustrations, emphasizing the simplicity with which the trained pilot changed his charts when necessary, the accuracy which ground-speed checks with Decca imparted to a predicted E.T.A., and the aid the airline pilot derived from the system as a whole. We hope to give abstracts from this paper in a subsequent issue.

The developments and forthcoming trials of Dectra were discussed by Mr. H. G. Hawker (Decca Navigator Co.) in his paper entitled *The Development of Dectra as a Long-range Navigational Aid*. He recalled that Dectra was one of the two British navaids [Delrac, another Decca proposal, was the second] recommended for evaluation at the March 1954 meeting of the I.C.A.O. Communications Division. Later this year, or possibly early in 1957, the system is to be tested under M.o.S. and M.T.C.A. auspices with the support of the Canadian Department of Transport.

The speaker then outlined the principles of Dectra, which used two master/slave pairs of ground stations, one pair at each end of the route to be covered. Each pair produced, by methods broadly similar to those of the basic Decca system, a hyperbolic pattern giving "tracking" information which spread out fanwise from the midpoint of the pair and thus gave increasing accuracy as the terminal area was approached. A "ranging" pattern, whose lanes crossed the route at regular intervals and gave distance-to-go along it, was generated by the two master stations, this facility being supplemented by a means of determining independently the distance from the aircraft to one of the masters.

Information obtained by the Dectra system would be displayed to the pilot by means of the familiar Flight Log, and slides were shown depicting typical Flight Log charts for the *en route* and approach phases of the north Atlantic crossing.

Dectra and the Decca System

A point emphasized by Mr. Hawker was the "integration" of Dectra with the basic Decca Navigator system, not only so far as the receiver (which would be of the new Mk 10 type) and the Flight Log were concerned, but also in relation to the ground stations. The master and the "purple" slave station of the North British Decca chain, respectively at Kidsdale and a site near Stirling, would form the eastern Dectra pair. The power of the stations would be raised to 5 kW. The actual Decca transmissions would provide the Dectra service, although for the latter the purple slave signal would act as the master. This signal was continuous except during lane identification, when it was switched off and a purple transmission of identical frequency was radiated momentarily from the master; thus the Dectra tracking pattern would be produced by phase-comparing master and slave signals at their carrier frequencies. The speaker added that this purple frequency, being at the low end of the Decca band, was particularly suitable for long-range transmission.

The western pair of stations would be at Comfort Cove (master) on the north coast of Newfoundland and Thornburn Lake (slave), five miles south of Port Blandford. It was remarked that these sites in Newfoundland were in ideal positions to form part of a Decca chain covering eastern Newfoundland, requiring only the addition of red and green slave stations. In conclusion, the lecturer referred to the large amount of practical data it was hoped the trials would provide, mentioning as a specific point of investigation the question of whether the proposed radiated power of the transmissions would prove adequate for 24-hour use all the year round.

The Development of Decca for Helicopter Operations, by Mr. J. G. Adam, was read by Mr. G. Hinchliffe (Decca Navigator Co.). Speaking of the coverage of the present Decca Navigator service in relation to the needs of helicopter operators, Mr. Hinchliffe said that so far as the U.K. was concerned the Navigator system provided solid area coverage over the entire country with the exception of the northern tip of Scotland and the western side of Ireland. In this area the fixing accuracy was better than 1½ nautical miles on 95 per cent of occasions at all times of the day and night throughout the year. Within the next few months the opening of the North Scottish chain would extend this cover northwards to beyond the Shetland Isles. Similar coverage was available over much of western Europe. It would seem that this accuracy would be adequate for the *en route* phase of helicopter flight between cities. It must be emphasized, however, that the accuracy figure quoted was the worst error which would be met at the edge of the area having this accuracy rating; throughout most of that area the fixing accuracy was very much better.

If the Flight Log were used, the relatively high-speed pattern fluctuations could be visually integrated so that only the slow drift remained. In these circumstances the 75 per cent probability figure could generally be taken as the fixing accuracy which would be achieved. In the London area the system was capable of giving a fixing accuracy of better than ±100 yd.

Where the accuracy available from existing Decca chains was not sufficient for A.T.C. or final approach, said the lecturer, the requisite high-accuracy local coverage could be supplied by a two-slave chain of low power costing about £10,000. With baselines five n.m. long at an angle of 120 deg the accuracy would be better than ±50ft over an area of some 20 square miles. Automatic equipment enabling the stations to run unaided would be used.

All the error figures quoted referred to random variations in the position-lines, and these did not contribute towards the collision risk when two Decca-equipped aircraft were in close proximity, since the two receivers would show the same error with respect to the ground. The main errors to be considered were those arising from incorrect adjustment of the receivers or from the inability of the pilot to fly the desired track. The Flight Log's pictorial presentation would seem to be the best solution to the helicopter-navigation problem, particularly when close lateral and longitudinal separation were involved. The total installed weight of the equipment (receiver plus Flight Log) was 40-100 lb.

Referring to developments now in progress, the speaker described a new technique whereby a route could be plotted on a Flight Log chart in the form of a long roll, any changes in pattern along the route being effected automatically. A self-setting Flight Log was under longer-term development, and here the pilot would have only to select the required chart and move the pen to within ±1in of the correct position, the pen thereafter positioning itself automatically on the correct spot within ±0.01in. Complete automaticity was possible but considerations of weight and equipment-complexity led to the conclusion that it was better to compromise. Both these developments would permit an accuracy of track-keeping in conformity with the I.A.T.A. requirement of ±500ft at 95 per cent probability. In conclusion, the lecturer referred to present investigations into the use of Decca for final approach. For this special lattice or Flight Log charts were employed showing the heights at which the aircraft should be at successive points along the approach path.

Points from the Discussion

The chairman, Capt. A. M. A. Majendie, then threw the meeting open to discussion. The first question concerned the variations in accuracy by day and night and in winter and summer of the Decca system. The questioner asked if trials of Dectra would be carried out by night as well as day, and inquired how the accuracy of the system could be measured, where no yardstick was available for checking. In reply, Mr. Hawker said that so far as the tracking accuracy was concerned a lot of evidence had been derived from the Danish chain by ships travelling to Iceland. It was known that the stability of the tracking lines would be very high, even in winter. It was expected that not more than two or three revolutions of the ranging Decometer would be lost in the course of a transatlantic flight, and the accuracy predictions took account of this.

Another question concerning Dectra referred to possible co-operation with Atlantic weather ships and U.S. Coastguard services. Mr. Hawker replied that co-operation did indeed exist and much help was expected from these organizations. It was hoped to place receivers on the weather ships.

Capt. Wright was asked if he made use of aids other than Decca on Viscount flights. An airline pilot, he replied, would always use all the available aids, if they were serviceable—that was the way to preclude errors. However, if he had to choose to fly on one aid, he would choose Decca.

Finally, Mr. Hawker was asked for information as to how static electricity might affect the Dectra system. He said that this problem was very prominent in the forthcoming trials, but the extremely narrow band width employed was a major advantage in this connection.

=Focus on the Hallmark=

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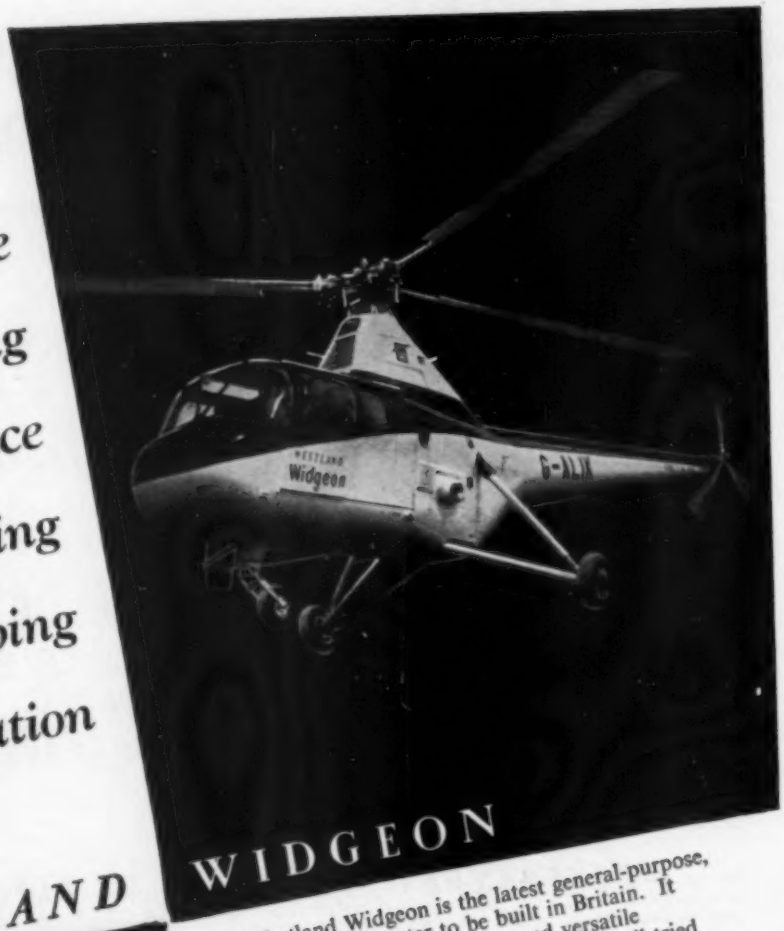

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THE Westland Whirlwind Helicopter is now available with the Alvis Leonides Major Engine as an alternative to the Pratt and Whitney Wasp engine. This powerful British engine gives the Whirlwind enhanced load lifting and hovering ability and increases the height attainable in forward flight. These additional attributes of a Helicopter that has already been proved during world-wide civil and military service are particular considerations where operation is required in countries where high atmospheric temperatures, humidity and altitude are determining factors.

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A typical production-type D.H.9, with B.H.P. engine.

THE DE HAVILLAND D.H.9

HISTORIC MILITARY AIRCRAFT No. 12 Part I

By J. M. BRUCE, M.A.

THIS, the twelfth article in Mr. Bruce's important series which has appeared periodically in "Flight" since October 1952, tells the story of a World War I bomber type which, though it did not win the affection of pilots to the same degree as its successor the D.H.9A, saw service in large numbers. The author wishes to acknowledge assistance he has received from Mr. A. R. Weyl, A.F.R.Ae.S., and Mr. D. B. Robertson in the compilation of this history.

STRATEGIC bombing had its beginnings in the operations of No. 3 Wing of the Royal Naval Air Service. From the outbreak of the 1914-18 war the Admiralty had been alive to the need for long-distance bombing attacks against naval and military centres lying within German territory, particularly those works in the Saar which were believed to be producing steel for U-boats.

But the means of launching such attacks were not available until the spring of 1916. By that time the Sopwith 1½-Strutter and Short Bomber were in production: the former, in its single-seat bomber version, could carry four 56-lb bombs; the latter could transport the substantial load of four 230-lb or eight 112-lb bombs.

The first 1½-Strutters became available in the spring of 1916, and at the beginning of May of that year Captain W. L. Elder, R.N., was sent to France to prepare for the arrival of the new bombing unit which was to be known as No. 3 Wing. It was hoped that by July 1st, 1916, the Wing would be equipped with twenty 1½-Strutters and fifteen Shorts, and that the ultimate strength would be one hundred aircraft.

Unfortunately for the unit, the first day of that July had been selected as the date of the launching of the great Somme offensive, and the R.F.C. was short, by no fewer than twelve squadrons, of the number of aeroplanes estimated to be required to meet the needs of the Army. The War Office appealed urgently to the Admiralty to hand over as many aircraft as the R.N.A.S. could spare; the appeal was promptly and generously answered by the transfer of a number of Sopwith 1½-Strutters, many of which had been destined for No. 3 Wing.

Thus it was not until October 1916 that No. 3 Wing was able to begin operations on a sizable scale. Attacks were made on iron and steel works at Hagendingen, Volklingen, St. Ingbert and Dillingen, but operations were hampered by unfavourable weather, and No. 3 Wing was disbanded in the spring of 1917 without having scored any resounding successes.

Some months later, when the enemy began his systematic night bombing attacks on London, it was officially decided to launch counter-attacks against targets in Germany, and the concept of strategic bombing was hurriedly resuscitated. At the beginning of October 1917, Maj.-Gen. H. M. Trenchard (later Marshal of the R.A.F. Lord Trenchard, whose death occurred last February) formed the 41st Wing, R.F.C., under Lt.-Col. C. L. N. Newall. The D.H.4s of No. 55 Sqn., the F.E.2bs of No. 100 Sqn., and the Handley Page 0/100s of No. 16 (Naval) Sqn. were based at Ochey, within reach of an area containing many vital industries. The attacks made by these squadrons on such towns as Saarbrücken, Volklingen, Kaiserslautern, Mannheim, Cologne, Mainz, Stuttgart and Coblenz damaged the enemy's industrial plants and lowered the morale of the workers in those towns.

In the weeks immediately preceding the establishment of the Independent Force, R.A.F., two new squadrons joined the 41st Wing. No. 99 Sqn. arrived at its aerodrome in France on May 3rd, 1918, No. 104 on May 19th. No. 99 made its first operational sortie on May 21st, and No. 104 on June 8th. Both units were day-bomber squadrons, intended to augment No. 55 Sqn., whose D.H.4s had given sterling service in the 41st Wing's daylight operations; and both were equipped with a new type of aircraft, the D.H.9.

When, therefore, the Independent Force officially came into being on June 6th, 1918, it consisted of Squadrons Nos. 55, 99 and 104 of the 41st Wing, and Nos. 100 and 216 of the 83rd Wing. So markedly had opinion swung in favour of strategic bombing that an ultimate strength of sixty squadrons was envisaged.

It might have been reasonable to expect the D.H.9, as a later design, to have been an improvement on the D.H.4. That it was not was unfortunate enough; but that it was ordered and put into service with its shortcomings known was a tragedy comparable to the continued production and use of B.E.2Es long after they had been outclassed.

The war-time fortunes of the D.H.9 were so intimately connected with its standard engine that it is necessary to begin by examining the history of the power unit. Perhaps, unexpectedly, that history began in France, in the summer of 1913 when a young British engineer named F. B. Halford examined a new water-cooled vee-eight engine of 150 h.p., built by the Hispano-Suiza company to the design of M. Birkigt. The Hispano-Suiza engine was of unusual construction, for each bank of cylinders was a monobloc aluminium casting into which steel liners, threaded over their whole length, were screwed. At that time it was customary for water-cooled aero-engines to have individual steel or cast-iron cylinders with sheet-metal water-jackets: the Hispano-Suiza engine therefore represented a considerable advance in design and constructional methods. It was probably not the first liquid-cooled aircraft engine to have aluminium cylinders, but it was indisputably the first successful one.

Halford immediately recognized the virtues of the new engine, and on his return to England he advocated the production of the Hispano-Suiza under licence. The engine had also been favourably reported on by Lt-Col. H. R. M. Brooke-Popham, who had examined it in Paris. The first British order, for fifty examples of the French engine, was placed in August 1915; and negotiations—which proved to be protracted—began with a view to its manufacture in Britain.

British production of the Hispano-Suiza did not begin until the spring of 1916, by which time Halford had nearly completed a new engine of his own design. He had earlier been largely responsible for increasing the output of the Beardmore six-cylinder engine from 120 h.p. to 160 h.p.: that development had been made in collaboration with T. C. Pullinger, managing director of Arrol-Johnston, Ltd., the company responsible for the manufacture of the Beardmore engine.

Early in 1916, in collaboration with Sir William Beardmore and T. C. Pullinger, Halford began work on a new six-cylinder in-line engine which incorporated an aluminium monobloc

The upper of these two photographs shows the prototype D.H.9—a converted D.H.4; the other is a production D.H.9 with small-diameter, four-bladed airscrew.

THE DE HAVILLAND D.H.9 . . .

casting, its use inspired by the Hispano-Suiza engine. As in the Hispano-Suiza, each cylinder had a closed steel liner threaded over its whole length and screwed into the aluminium block. The new engine was known as the B.H.P., signifying Beardmore-Halford-Pullinger; and the first example was running on the bench in June 1916. It delivered a little over 200 h.p. The first B.H.P. engine was installed in the prototype D.H.4, which appeared at Hendon in August 1916 and successfully underwent official trials in the following month. (The engine originally specified for the D.H.4 had been the 160 h.p. Beardmore, but the B.H.P. was of similar configuration and fitted into the airframe reasonably well.)

A new company, the Galloway Engine Co. Ltd., of Dumfries, was formed to exploit the new power unit. The engine was then named the Galloway Adriatic, and was ultimately rated at 230 h.p. The name Adriatic found little acceptance, however, and few references to it have survived. The 230 h.p. B.H.P. was put into production on a modest scale at Dumfries. Events were to bring about an enormous expansion of that production.

In June 1916 Sir Douglas Haig submitted an expansion programme for the R.F.C. which would provide for 56 squadrons on the Western Front by the spring of 1917. In September 1916, however, the enemy introduced his new and deadly Albatros and Halberstadt fighters, and with their appearance an urgent need arose for substantial numbers of more and better British aircraft. In November Haig asked for an additional twenty squadrons for service on the Western Front, and by the end of the year the total number of approved R.F.C. squadrons for all theatres of war had risen to 203, of which 97 were to be training units.

It was estimated that approxmiately 8,000 engines would be required to maintain these squadrons, and that British production of aero-engines would have to reach a rate of 2,000 per month. In December 1916 output was about 600 engines a month.

The Air Board was re-organized in January 1917, and responsibility for all aircraft supplies was transferred to the Ministry of Munitions. A production programme of 2,000 engines a month was prepared in January 1917, but it was obvious that it could not be realized before the autumn. At that time, forty different types of engine were in production, and steps were therefore taken to standardize certain engines in order to speed up production. In the 200 h.p. category it became necessary to choose from four types: the B.H.P., a six-cylinder Sunbeam (presumably the Saracen), the Hispano-Suiza, and a vee-eight Sunbeam which was to be known as the Arab.

The internal combustion engine sub-committee of the Advisory Committee for Aeronautics was asked by the Air Board to assess these engines and to decide which was most suitable for mass-production. At the end of January 1917, after a thorough appraisement, the sub-committee recommended the adoption of the Sunbeam Arab, then a new and untried design. They also recommended the B.H.P. engine as being superior to the Saracen. Both Arab and B.H.P. were ordered in large numbers: a total of 4,400 Arabs were ordered from the Sunbeam, Austin, Lanchester and Napier companies and from the Willys-Overland concern in America; and mass-production of the B.H.P. engine was made the special responsibility of the Siddeley-Deasy Motor Co., Ltd., of Coventry, from whom 2,000 engines were ordered. Additionally, the Hispano-Suiza was to be produced by the Wolseley company.

All three of these types embodied aluminium monobloc cylinder construction, and the extent of the reliance placed upon what was then a new departure may be assessed from the fact that, of all the engines due for delivery between June and December 1917, no fewer than 4,000 depended upon the successful production of aluminium blocks. This fact, particularly where the new and untried Sunbeam Arab was concerned, so perturbed Capt. R. H. Verney of the Aeronautical Inspection Directorate that he wrote to the internal combustion engine sub-committee, expressing his doubts about the successful production of aluminium castings and inviting the sub-committee's attention to many details of the Sunbeam Arab which were still experimental. The sub-committee then reconsidered their findings, but saw no reason to change them; they further expressed the opinion that the expected difficulties in the production of aluminium castings would not be insuperable.

The subsequent melancholy history of the Sunbeam Arab is not appropriate to this narrative. Suffice it to say that, as a failure, it was probably surpassed in magnitude only by the A.B.C. Dragonfly radial engine.

The B.H.P. engine was much more of a known quantity when it was ordered into large-scale production, for it had performed satisfactorily on test and the small numbers built by the Galloway Engine Co. had shown no serious defects. To render it suitable for mass-production, however, a number of modifications had to be made. The changes inevitably delayed production, and brought in their train a number of subsequent modifications after air tests of the first Siddeley-built engines.

Large-scale production of the B.H.P. engine was ordered at the time when the recommendations of the Burbidge Committee * were implemented and many members of the staff of the Royal Aircraft Factory were released to serve in the aircraft industry. In January 1917 Capt. (later Maj.) F. M. Green joined the Siddeley-Deasy company and was appointed chief aeronautical engineer. He brought Mr. S. D. Heron with him from Farnborough. Capt. Green's primary task was to develop the B.H.P. engine and to adapt it for production; Heron was given the task of developing the R.A.F.8 radial engine, which was ultimately to emerge as the Armstrong Siddeley Jaguar.

Mr. J. D. Siddeley himself took a hand in the development of the B.H.P. engine, and it was at his instigation that the cylinder design was modified to incorporate an open steel liner with a short screw-thread on its upper end by which it was screwed into the cast aluminium cylinder block. (The original B.H.P. engine had a closed liner threaded over its entire length.)

As modified for mass-production by the Siddeley-Deasy company the engine was named Siddeley Puma. But the modifications which resulted in the Puma did not alone ensure trouble-free production. At an early stage, Capt. Verney's prognostications about the difficulties likely to be encountered in the production of aluminium cylinder blocks were realized. By July 1917 sufficient Puma cylinder blocks were available to permit an output of 100 engines per month, but it was soon found that 90 per cent of the cylinder blocks were faulty. A report made that month to the Air Board stated that defective castings accounted for 20 per cent of the rejects, porousness for 35 per cent, and damages sustained during machining for a further 35 per cent; and a few which had no obvious flaws failed on test.

Trouble with the aluminium castings persisted throughout the summer of 1917 and was responsible for a six-month set-back to the production schedule. These difficulties may have been the reason why, in order to ensure the availability of some engines, the Galloway Engine Co. experimented with a version of the B.H.P. which had cast-iron cylinders. It appears that the difficulties with aluminium castings were ultimately resolved, for production of the engine began to gain momentum. A further difficulty was encountered when it was found that the exhaust valves were prone to burn out rapidly, and more delays occurred while this fault was remedied. Production did not really get under way until the spring of 1918. During the first three months of that year

**The Burbidge Committee (Chairman: Sir Richard W. Burbidge, Bt.), was set up by the War Office in March 1916 to enquire into the functions of the Royal Aircraft Factory. Among its recommendations was one to the effect that the Factory should confine its activities strictly to research and should not build even experimental aircraft.*

798 B.H.P. and Puma engines were built, whereas the output for the last three months of 1917 had been only 241. By October 31st, 1918, however, the R.A.F. had more Pumas on charge than any other individual type of engine: the total was 3,255, in addition to which 89 Galloway Adriatics were held.

German bombers demonstrated the effectiveness of daylight bombing in the summer of 1917, when they made several attacks on Southern England. The telling London raid of June 13th, 1917, forcefully impressed on the Cabinet and population that bombing by aeroplanes represented a serious threat, and the Air Board was requested to submit a scheme for the expansion of the British aerial forces. On June 21st a meeting was held at the War Office, and it was decided to increase the number of service squadrons of the R.F.C. from 108 to 200. It was intended that the majority of the additional squadrons were to be bomber units.

The Cabinet approved the proposal on July 2nd, and Sir Douglas Haig was informed of the decision on July 13th, in order that he might begin to seek the additional aerodromes which would be needed to accommodate the new squadrons. Haig was not enthusiastic about the nature of this expansion of the R.F.C. which, he maintained, had been planned without regard to the requirements of the British armies in France. He was anxious to see priority given to the establishment of the 76 squadrons he had asked for in November 1916, with the addition of 10 bombing squadrons for attacks on German aerodromes. Finally, the War Office specifically asked Haig to provide for the accommodation of 40 squadrons additional to the 86 he himself regarded as the essential minimum. He was to assume that the last of the squadrons would reach France by the end of August 1918.

Haig was therefore entitled to assume that, in a little over twelve months, he would have 50 squadrons available for long-distance operations. He began immediately to arrange for the accommodation of 40 of the units in the British zone and for ten in the French zone near Nancy, where they would be close to the numerous targets lying in the Rhine industrial areas. On August 24th, 1917, he wrote to the War Office, pointing out that enemy fighter opposition to the proposed raids would be intense, and that he thought it would be necessary for 25 per cent of the participating aircraft to fly, without bombs, as escorts to the bombers. For this purpose he recommended that the escorts should each have at least four machine-guns, two firing forwards and two rearwards.

The question of the type of aircraft which should equip the new squadrons had been considered by the War Office. The official choice fell first on the D.H.4, a type which was already in production. Some minor modifications were envisaged, but it was made an overriding condition that their incorporation must not delay production. Sir Douglas Haig was also told that efforts were to be made to produce a design which would have a longer range than the D.H.4. In June 1917 a total of 700 D.H.4s were ordered for the equipment of the new bomber squadrons.

On July 23rd, 1917, the controller of technical design laid before the Air Board plans of an extensively-modified D.H.4. So extensive were the modifications, in fact, that the aircraft had been given the new designation D.H.9. The B.H.P. engine was to be fitted. In support of the new type it was stated that "whereas the D.H.4 lost 17 miles an hour when flying fully loaded at 10,000 feet" (the authority and validity of that statement are questionable) the D.H.9 would retain its speed of 112 m.p.h. at that height and would have a greater range.

The Air Board did not immediately transfer their favour to the D.H.9, but at a further meeting on July 26th an assurance was given that adoption of the new type would cause only an initial production delay of some three to four weeks. It was thereupon decided to adopt the D.H.9 in preference to the D.H.4.

It is perhaps as well to remember that, at that time and in the light of the information and assurances given to the Air Board, the decision was probably justified. A possible reason for early optimism over the D.H.9's performance is the fact that the first few Siddeley Pumas were rated at 300 h.p.; but the troubles experienced with the cylinder blocks led to the derating of the engine to 230 h.p.

The prototype D.H.9 was A.7559, a converted D.H.4, and was flying in July 1917. It was powered by one of the Galloway-built B.H.P. engines and, even without bomb load, its performance fell short of the estimates given to the Air Board. The first production D.H.9, C.6051, was tested in November 1917 with a Siddeley-built B.H.P. engine. With two 230-lb bombs the speed proved to be 111.5 m.p.h. at 10,000ft; but a month later, by which time a clear-view cut-out had been made in the lower starboard wing root and the engine's total flying time had reached 55 hours, the speed was down to 104.5 m.p.h. at 10,000ft and the aircraft could climb little above 15,000ft.

It was obvious that the D.H.9 fell short of requirements, a fact which seriously disquieted Maj-Gen. H. M. Trenchard as soon as he learned of it. As early as November 16th, 1917, he wrote to Maj-Gen. J. M. Salmond, the then Director-General of Military Aeronautics, to say that Mr. Geoffrey de Havilland had told him unofficially that the D.H.9 would have a poorer performance than the D.H.4 with the 275 h.p. Rolls-Royce engine. Trenchard expressed his opinions in these characteristically forthright terms:—

"I do not know who is responsible for deciding upon the D.H.9, but I should have thought that no-one would imagine we should be able to carry out long-distance bombing raids by day next year with machines inferior in performance to those we use for this purpose at present. I consider the situation critical and I think every endeavour should be made at once to produce a machine with a performance equal at least to the existing D.H.4 (275 Rolls-Royce) and to press on with the output with the utmost energy. . . . I am strongly of opinion that unless something is done at once we shall be in a very serious situation next year with regard to this long-distance day bombing. . . ."

Two days previously, on November 14th, Sir Douglas Haig had requested that orders for the D.H.9 be reduced to provide sufficient aircraft for the equipment and maintenance of only 15 squadrons. This request was, of course, inspired by Trenchard, for it was his opinion that the D.H.9 would be outclassed by June 1918. Events were to prove him correct.

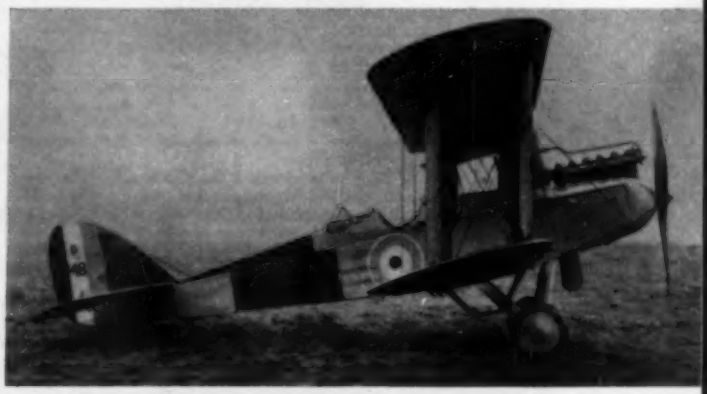
Salmond urgently reported Trenchard's opinions to the Air Board, but was told by Sir William Weir, the Controller of Aeronautical Supplies in the Ministry of Munitions, that the choice lay between the D.H.9 with the B.H.P. engine or nothing at all. On November 28th Trenchard attended a meeting of the Air Board and bluntly stated his objections against the aircraft.

At that time no D.H.9 had reached France (indeed, only five were completed by the end of 1917). It seems hardly credible that the grim lesson of the B.E.2C and 2E had not been learned, and that another type of inadequate aircraft was about to be introduced into operational service. What charged the situation with the element of catastrophe was the fact that the D.H.9's imperfections had been recognized before it went into service. It would be unjust to describe the machine itself as a bad aeroplane. It was in fact a sound, comfortable and tractable aircraft, marred by an engine which was insufficiently powerful and unreliable to a degree, and which was obsolete at the time of its selection as the D.H.9's standard power unit.

Structurally the D.H.9 differed little from its predecessor, the D.H.4. The mainplanes and tail unit were in fact identical. The wings had spruce spars which were spindled out between the compression struts, and the ribs had plywood webs. The internal bracing was of wire; externally the D.H.9 was braced as a conventional two-bay biplane with spruce struts and Rafwires. Ailerons were fitted to upper and lower wings, and the spanwise balance cables ran externally above the upper wing. The tail unit was likewise a wooden structure, and incorporated the same variable-incidence tailplane and horn-balanced rudder which were fitted to the D.H.4.

It was in the design of its engine installation that the D.H.9 differed markedly from the earlier type. All the standard engines fitted to the D.H.4, with the exception of the Fiat A-12, had frontal radiators; and the pilot sat directly under the centre-

D.H.9 with Fiat engine. (Bottom) A standard D.H.9 (to be compared with the Fiat-powered machine).



D.H.9 modified for night flying, with long "pepper-pot" exhaust-pipe to act as a flame-damper and silencer.

THE DE HAVILLAND D.H.9 . . .

section, separated from his observer by the main fuel tanks, which were installed between the cockpits. On the D.H.9, however, the engine was only partly cowled: above the blunt cowling the cylinder heads and exhaust manifold were completely exposed. The radiator was mounted in the ventral position, immediately in front of the undercarriage legs, and was retractable: it moved vertically, and was actuated by a simple rack-and-pinion mechanism which was connected by an endless cable to a hand-wheel on the starboard side of the pilot's cockpit.

The pilot sat behind the wings, and he and the observer were close together. The main fuel tank was installed immediately behind the engine. Between this tank and the pilot's cockpit there was an internal bomb-bay which could accommodate two 230-lb bombs or an equivalent weight of smaller bombs. The "Hunnish" engine cowling and the rearward position of the pilot's seat combined to make the D.H.9 look quite different from the D.H.4, despite its close relationship to the earlier type.

The construction of the fuselage was reminiscent of the D.H.4. It was a wooden structure, with wire cross-bracing abaft the observer's cockpit; the forward portion embodied several wooden diagonal members and was plywood-covered. The lower longitudinals embodied sturdy *patons* which extended rearwards from the forward undercarriage legs to the rear of the observer's cockpit. Extensive use was made of plywood for formers, and the rearmost bay of the fuselage was plywood-covered. The undercarriage had two substantial wooden vee struts, to the apices of which the axle was bound by rubber cord. The steel-shod wooden tail-skid was also sprung by rubber cord. As on the D.H.4, the observer's cockpit contained a dual set of flight controls, but engine controls were not duplicated.

The main petrol tank was divided longitudinally into two separate compartments, each of which was fitted with a windmill-driven pump. Provision was made for the two compartments of the tank to be interconnected in the event of failure of one of the pumps. Fuel was pumped up to the 8-gallon gravity tank in the centre-section, whence the engine was fed. The main tank was clothed in a loose cover of doped fabric which was intended to drain petrol away rapidly if the tanks were hit.

From his position behind the wings the pilot had a good view in most directions. In an attempt to improve his downward view a cut-out was made in the root of the starboard lower wing. With its pilot and observer close together, the D.H.9 ought to have been a better combat aircraft than the D.H.4, but the improved seating arrangement did not compensate for the lack of the performance necessary to evade the German fighters.

The D.H.9 was placed in production on a large scale with several contractors. Deliveries did not begin until the end of 1917, but production gained momentum rapidly until output was at the rate of one complete aircraft every 40 minutes. Peak production was reached in the middle of 1918: during the quarter which ended on June 30th, 1,156 D.H.9s passed inspection, and during the next three months the total was 1,052. During the final quarter of the year, 660 were passed.

Although the D.H.9 will always be associated with the Independent Force, it had its baptism of fire in the hands of Squadrons Nos. 98, 206 and 211. All three of these units were in France by April 3rd, 1918; Nos. 98 and 206 were with the II Brigade, while No. 211 was allocated to the VII Brigade. As the three D.H.9 squadrons were arriving in France, enemy activity began to increase in the La Bassée area, and by April 6th it was evident that preparations for an offensive north of Aubers were well advanced. Any doubts about the enemy's intentions were dispelled by a heavy bombardment with mustard-gas shells on the night of April 7th/8th, and on April 9th the German Sixth Army attacked along a line between Armentières and the La Bassée canal. The Battle of the Lys had begun.

The D.H.9s of No. 206 Sqn. had already been in action. On April 2nd they had twice raided Don railway station, and on the 7th had dropped five 112-lb and eighty-seven 25-lb bombs on Haubourdin station. By April 11th, the Battle of the Lys was raging fiercely, and Nos. 98 and 206 Sqns. bombed Wervicq and Armentières. On the following day Sir Douglas Haig issued his famous "backs to the wall" order; during that day nineteen pilots of No. 206 Sqn. flew a total of 76 hours. The morning found them, in company with No. 98, attacking German lines of communication at Comines, Quesnoy, Frélinghien and Haubourdin; and in the afternoon of that critical day both units were diverted to the Merville area. The D.H.9s of No. 98 Sqn. dropped a total of fifty-five 112-lb bombs from 2,500ft on enemy troops and transport at Neuf Berquin, Estaires and Steenwerck. At 6.30 p.m. No. 206 Sqn. dropped twenty-one 112-lb bombs on targets between Armentières and Estaires. Bad weather hampered bombing activity during much of the remainder of the battle, which ended on April 29th.

Despite the good work it did as a tactical bomber, the D.H.9 is best remembered for its service with the Independent Force and for the strategic bombing it performed with the squadrons of that Force. As the Battle of the Lys was ending, most of the D.H.9s and crews of No. 99 Sqn were at St. Omer, awaiting suitable weather for their flight to their aerodrome at Tantonville, south of Nancy. The opportunity came on May 3rd, but the 240-mile flight was too much for the engines of the aircraft, which provided a foretaste of the troubles which lay ahead—broken valve springs and minor defects were found on nearly every engine.

Soon after their arrival at Tantonville, the pilots of No. 99 Sqn. discovered the D.H.9's woeful lack of operational performance. The squadron history records:—

"It was found that single machines could seldom climb above 16,000 feet in 75 minutes without bombs, or 14,000 feet in the same time with one 230-lb or two 112-lb bombs. Most engines ran very badly, and used far too much petrol above 10,000 feet, owing to the defective altitude control on the Zenith carburettor. This was afterwards enormously improved by a Squadron modification, and the average petrol consumption reduced from about 15 gallons an hour to less than 13."

That history contains many references to engine trouble; the repeated defections of the Pumas constitute a kind of continuous accompaniment over which themes of determination and gallantry are woven simply, starkly or magnificently:—

"The 29th (of May) was a thoroughly unlucky day. Fourteen machines of 'A' and 'C' Flights started for Thionville, 32 miles over the lines. Finally, only six machines completed the raid. Of the eight which failed to cross the Lines, one machine broke a petrol pipe, another had a broken oil pipe, and a third a badly missing engine; the remainder were unable to keep up at a height owing principally to defective vacuum control and broken valve stems."

A later entry reads:—

"Eventually only six machines performed the raid [on Metz, June 1st, 1918] out of the thirteen which started. The majority of the machines which did not cross the Lines were unable to keep pace at a height, and it was agreed, after talking the matter over, that leaders should attempt rather to take full formation over the Lines than to climb an extra 500 feet, which would in any case be insufficient to enable the D.H.9s to avoid the German scouts . . . . At this time the Squadron was passing through a period of depression. One or more valve springs had broken on at least three out of four engines which went up on a raid, and this, combined with frequent carburettor and petrol pipe troubles, made it most difficult for the fitters to keep the engines serviceable . . . . The pilots and observers were also much downcast by the frequent failure of the machines even to reach 13,000 feet in a reasonable time when carrying bombs . . . . An expert from the Siddeley Company was attached for about ten days at this time, who helped considerably, but was unable to discover anything in connection with the maintenance of engines beyond what was already known to Chief Master Mechanic Martin. The first case of a cracked cylinder head was now found on an engine, and these became more frequent as the weather became warmer."

The bogy of engine trouble recurs time after time:—

"On June 4th . . . the two emergency machines returned after seeing twelve machines across the Lines, but unfortunately two others were compelled to return shortly afterwards, Lt. Beecroft with a broken oil pipe, and Lt. Marshall with a cracked cylinder head."

"Engine trouble again defeated the Squadron on the 6th, only eleven machines of 'A' and 'B' Flights actually getting into the air, of which six finally returned without crossing the Lines."

"The next day's work was even more depressing, as only four machines reached Thionville, under Capt. Purser, out of the twelve which started from 'B' and 'C' Flights. Several machines . . returned with various engines troubles. . . ."

(*Continued on page* 392)

No other Anti-submarine Aircraft

is so compact, efficient and economical as the Gannet.
It combines in a single aircraft the ability to search and strike with the most formidable modern weapons, has twin engine reliability and is equally suitable for ship or shore based operations.
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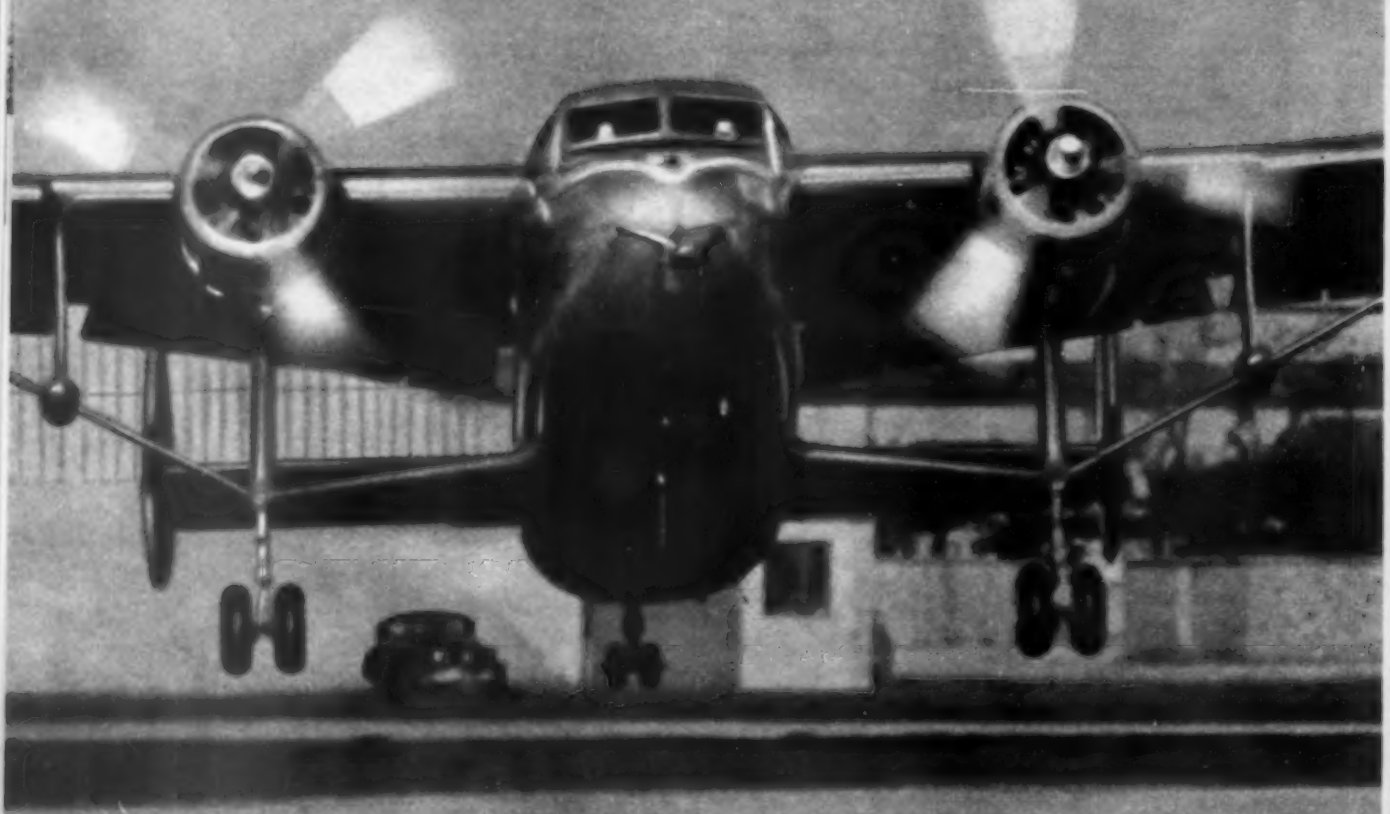


DE HAVILLAND PROPELLERS

As already recorded in "Flight", a de Havilland Vampire Trainer has been demonstrated in Japan by George Errington. It is seen at the Air Self-Defense Force's Hamamatsu base.

AIRCRAFT INTELLIGENCE

Great Britain

Handley Page Herald (Military Version). In the projected military version of the Herald the floor is reinforced to carry concentrated loads and there are changes in the size and position of doors. Provision is also made for the fitting of paratroop static lines. Weight increase is 800 lb. The starboard emergency exit is replaced by a paratroop door 6ft high and 3ft wide, and the main loading hatchway on the port side of the rear fuselage is increased in size. Still-air radius of action (no allowances) with 40 paratroops is 265 miles, or with 32 paratroops 525 miles. Twenty 350 lb panniers, or their equivalent in 500 lb containers, can be carried. The containers are dropped by means of a roller conveyor. Typical loads are a jeep or Land Rover and trailer; a 25-pounder gun and ammunition; two aero engines; or one aero engine with equipment, tools and servicing crew. In the trooping rôle 44 troops with equipment and baggage could be carried over a still-air range (no allowances) of 500 miles.

U.S.A.

Douglas B-66. The first B-66 tactical bomber, with two Allison J71 turbojets, has been delivered to the 17th Bomb Wing of Tactical Air Command's Ninth Air Force at Hurlburt A.F.B., Florida.

Boeing B-52 Stratofortress. According to *Aviation Week*, pilots of B-52A and B and RB-52B aircraft at Castle Air Force Base have taken their machines well over 50,000ft by pushing the Pratt and Whitney J57 turbojets to the limits. Above those altitudes it is reported a compressor stall problem arises. Pilots report that the B-52 is more stable, more controllable and more responsive for air-refuelling than the B-47, notwithstanding the fact that the refuelling intake is above and behind the pilot. At light weight (i.e., returning from a sortie) the B-52 can fly the traffic pattern at the same speeds as the DC-6 or DC-7.

Chance Vought F8U Crusader. Deliveries of this 1,000-m.p.h. fighter should be made to the U.S. Navy during 1957. Initially the type will have no all-weather capability, but this should be provided later with some sacrifice in performance.

France

Marcel Dassault Production. Though the production of 150 Mystère 2 (S.N.E.C.M.A. Atar) fighters is now nearly complete, the Mystère 4 line is in full swing, and the type will go into service with several French squadrons this year. Additionally, five pre-production Super Mystère B.2s (S.N.E.C.M.A. Atar with afterburner) will be completed this year, and the production of several hundred B.2s will begin early in 1957. The prototype Super Mystère B.1, powered with an afterburning Rolls-Royce Avon engine, is being flown regularly by Commandant Boudier and has recently attained 900 m.p.h. in a dive.

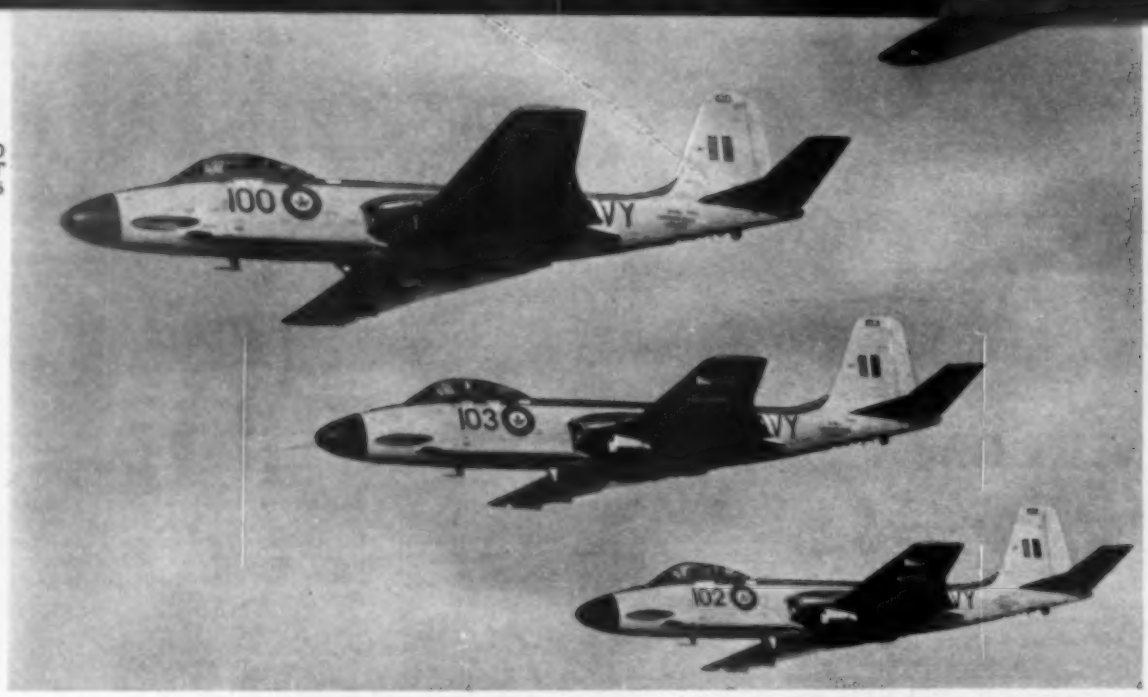
Czechoslovakia

Aero 145. This new prototype is a 4/5-seater and represents a big improvement on the Aero 45 and has two 160 h.p. engines. Top speed is 186 m.p.h.

Australian Negotiations. The Czech aircraft industry is hoping to sell a considerable number of light aircraft in Australia. The Zlin 126 Trener and the new Aero 145 will be shown at an engineering exhibition in Sydney next June, and it is reported that negotiations have already been opened with an unnamed Australian firm for a large batch of these aircraft, provided they satisfy specified conditions.

TUPOLEV Tu-104
(Two axial-flow turbojets)

Span	... ...	120ft (approx.)
Length	... ...	126ft (approx.)



CANADIAN NAVAL AVIATION

Current Equipment and Organization Reviewed

By a Canadian Correspondent

WITH the prospect of a new carrier from the Royal Navy by the fall and with newly-acquired Banshee all-weather naval jet fighters, the air arm of the Royal Canadian Navy is entering a new phase of its hybrid post-war career.

In the vanguard of the R.C.N.'s new look in aviation is a list of brand-new aircraft ready to carry on the job of offensive and defensive anti-submarine warfare. During the coming months squadrons are being equipped with McDonnell F2H-3 Banshee all-weather, long-range fighters, more Lockheed T-33 jet trainers, and half a dozen S-55 helicopters and tandem-rotor Piasecki HUPs. Still being manufactured (in Canada by de Havilland) are the Grumman CS2Fs on whose delivery the R.C.N. places no firm date. It will probably be mid-1957.

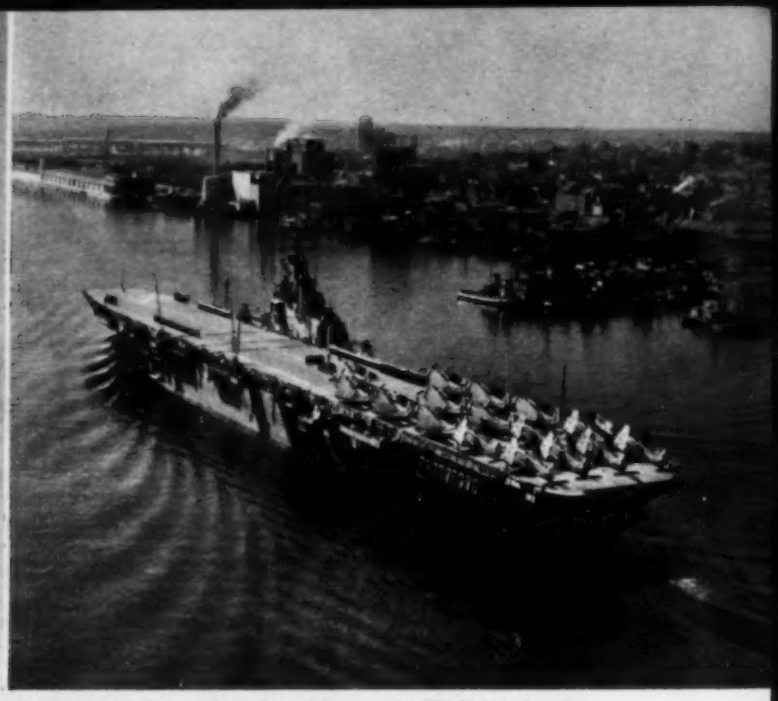
Canadair-built Lockheed T-33 naval jet trainers from R.C.N. Air Station H.M.C.S. "Shearwater" swing low over the new Angus Macdonald Bridge, between Dartmouth and Halifax, N.S.

The varied nature of today's Canadian naval air power is basically three-fold—Canadian personnel, U.S. aircraft and British ship-borne gear for aircraft handling and flying. Since its creation late in the last war, the naval air commitment of training and exercises has been undertaken to a large degree in U.S.-built aircraft and British-built ships. Added to this is the fact that pilot, observer and specialist ground crew training has had to be done both at home in Canada and abroad in the United Kingdom or the U.S.A. Thus we find today a naval air service in the British Commonwealth which has benefited from both the achievements and mistakes of aircraft and training development since 1945 in both the U.K. and the U.S.A.

Today, with its own base at H.M.C.S. *Shearwater*, near Halifax, N.S., with enough aircraft for present duties in training, experimental and operational flying, and with the light fleet carrier H.M.C.S. *Magnificent*, Canada's naval air arm has come a long way in the last decade. Indeed, the Canadian Service has grown up within that period. Its origins were certainly not indicative of the post-war future it was to have nor of the future potentialities of the air aspect of war at sea.

Quite often during the war the then Canadian Chief of Naval Staff, the late Admiral Percy Nelles, R.C.N., had to couch suggestions for naval air service funds with the idea of training men and buying ships for the day when the war would be over. In a war committee of the Canadian Cabinet on November 10th, 1943, the Prime Minister stated that the Government was not justified in wartime to authorize expenditures related to the post-war period. By mid-1944, however, the Navy had two escort carriers, H.M.C.S. *Nabob* and *Puncher*, of about 15,000 tons each. Manned jointly by R.N. and R.C.N. crews, they saw service in the last year of the war. *Nabob* was torpedoed in a strike against the Norwegian coast in August 1944, and *Puncher* was returned to the Royal Navy under the arrangement which brought the new fleet carriers *Warrior* and, later, *Magnificent*, into the Royal Canadian Navy.

By virtue of its needs for trained personnel the Service has been as hybrid in its manning programmes as it has been in taking on ships and equipment. From the early days when R.N., R.N.V.R. and R.C.N.V.R. pilots and crews fought in the first escort carriers up to the present time, when trained R.N. helicopter pilots are on staff at the Canadian Naval Air Station, Canadian, British and



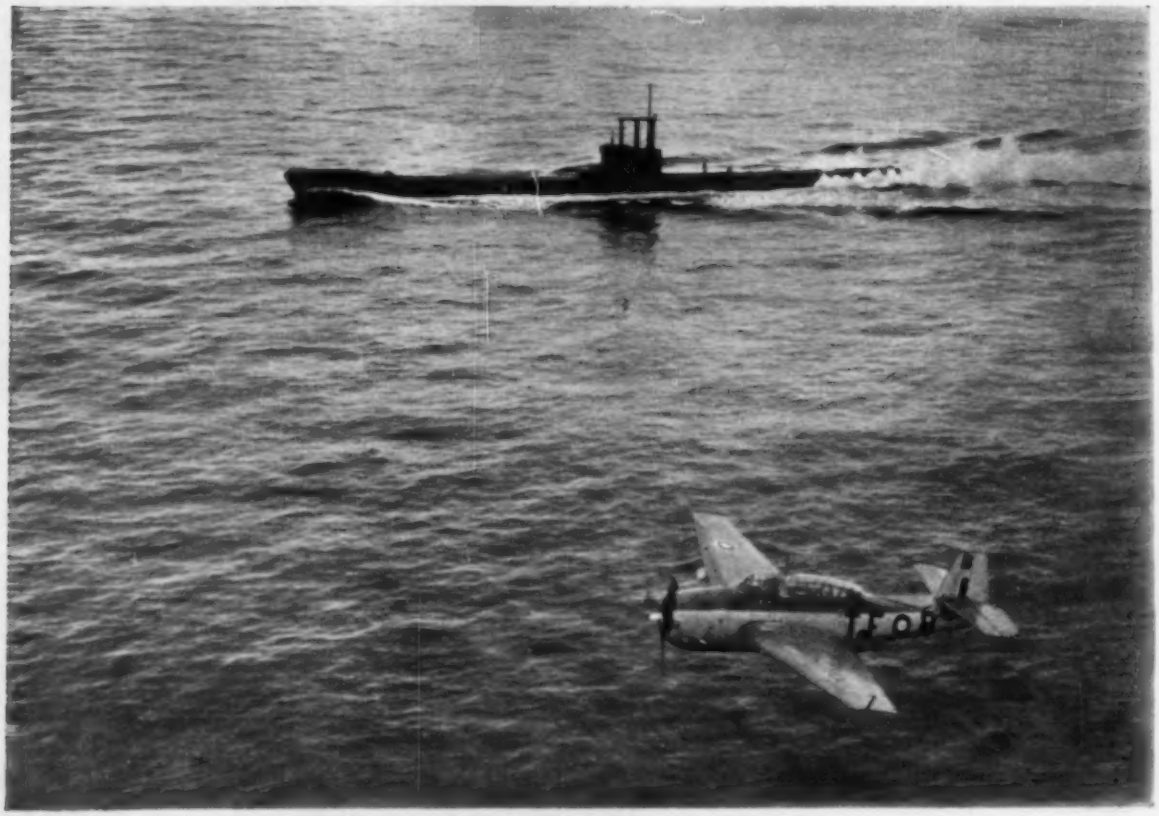
Left, McDonnell F2H-3 Banshee twin-jet fighters, latest machines of their class in R.C.N. service. They belong to No. 870 Fighter Squadron, based at Dartmouth, Nova Scotia, and will operate from H.M.C.S. "Bonaventure." Centre, a Grumman S2F, forerunner of the Canadian-built CS2F-1 anti-submarine aircraft. Right, H.M.C.S. "Magnificent" steaming out of Halifax on a NATO exercise, with Sea Furies secured astern. Below, an Avenger on exercises with the Royal Navy "A" class submarine, on loan to the R.C.N.

American personnel have all served in the Canadian naval air service. At the present time, the Assistant Chief of Naval Staff (Air) for Canada is a senior R.N. officer from the Fleet Air Arm. Right now, he is a Commodore (P) on loan.

Over the last ten years, flying personnel have come from the R.A.F., R.C.A.F. (after retirement at the end of the war) and R.N.V.R., with the occasional officer from a Commonwealth naval component such as the Royal Australian Navy.

From H.M.C.S. *Shearwater* the R.C.N. today operates squadrons devoted to the following duties: anti-submarine attack, utility, training for pilots and observers, helicopter utility, helicopter anti-submarine attack, experimental work, and anti-submarine jet attack.

Squadrons bear the standard symbolic letters and numbers as used in the United States Navy. For example, VS 880 and VS 881 are anti-submarine attack squadrons; VT 40 is a training squadron doing advanced flying training and instrument flying training; VU 32 is a utility squadron working closely with



CANADIAN NAVAL AVIATION . . .

H.M.C. Observer School; and VX 10 is an experimental squadron, which tests new aircraft and anti-submarine equipment.

VF 870, the only fighter squadron to receive Banshees to date, completed familiarization flying on the type at the U.S.N. base at Cecil Field, Jacksonville, Florida. This included ground-crew and engineer training as well as flying practice. The two anti-submarine squadrons which may be the first to get the Grumman CS2Fs, VS 880 and VS 881, completed five months afloat in H.M.C.S. *Magnificent* just before Christmas of last year.

The helicopter squadrons use only American-built aircraft, such as the newest Sikorsky HO4S as well as the Piasecki HUP-2. HU 21 is the helicopter utility squadron which does search and rescue, radar calibrations with ships, and "fish drops" for the Federal Department of Fisheries. HS 50, the newest of the helicopter squadrons, is engaged in work of a classified nature concerning uses of asdic equipment or "dunking sonar." Its aircraft are the HO4S (S-55) and HSS (S-58).

Another feature of R.C.N. air research which came into its own last year is the work of helicopters in Arctic waters. During the 1955 cruise of H.M.C.S. *Labrador*, the Navy's new icebreaker, first vessel ever to circumnavigate the North-west Passage, two single-rotor Bell HTL-4s and a tandem-rotor Piasecki HUP were aboard. The machines were used in open-water searches ahead of the icebreaker and in ocean-bottom soundings in connection with hydrographic surveys.

The R.C.N. has recently decided not to train nor recruit further commissioned observers. At present (O) officers will complete their initial commitment and may try for pilot (P) classification or stay in the Service as executive officers. This will mean obtaining a watch-keeping certificate and, if they desire, specializing in one of the regular professional subjects of the Navy. Especially in helicopter squadrons, the replacement of one observer and one pilot by two pilots has had its repercussions. While it is recognized that helicopter flying can be most tedious and a serious strain on a pilot, those who wish to see (O) officers retained ask how regular (O) duties can be carried out by officers trained primarily as pilots.

There have been problems of aircraft procurement. Chief of these was the five-month strike at the de Havilland Canada factories which began just after tooling for manufacture of the CS2F had begun. The firm is making this aircraft under contract from Grumman in the U.S.A. Unfortunately for R.C.N. training schedules, the new sub-killer now looks like being out of the picture for at least another 12 months—maybe more.

In the last two years the development of a Naval Air Reserve in Canada has been undertaken. At present, there are reserve squadrons in five Canadian cities. The oldest and largest is VC 920 of Toronto. Flying Harvards and Avengers, their reserve pilots completed deck landing qualifications this summer on board H.M.C.S. *Magnificent*. This was the first time in the history of the Canadian Navy that "week-end sailors" have qualified as carrier pilots.

Like their permanent-force counterparts, they still have as their main aircraft the Grumman Avenger, once used by the U.S.N. for front-line air sweeps in the Pacific. Reserve pilots will not, however, fly the Sea Fury—which, like the Avenger, will be a thing of the past when the new aircraft arrive.

The strong preponderance of U.S. aircraft and equipment in the R.C.N. is not difficult to understand. In this age of sudden supersonic attack which can be initiated and carried out in a few hours, sources of equipment-supply cannot be 3,000 miles away in the United Kingdom. Logistical and regional reasoning win out over sentimental ones when the cold war can change overnight to a hot one. With U.S. sources a few hundred miles away and liaison a matter of a short flight, the R.C.N. is certain to continue to rely on the U.S. aircraft industry for its aircraft.

It has been a brief but progressive decade for naval air power in Canada. Operating as the new medium of warfare that it is, in a Service devoted since the dawn of history to fighting on the surface of the sea, air power in the Royal Canadian Navy today has assurance, a record to point to, acceptance by the nation and a sound future in the jet air age.

THE DE HAVILLAND D.H.9 (Continued from page 388)

"On June 8th . . . of the five machines which returned with their bombs, Capt. Taylor's broke the magneto drive; Lt. Richards' engine would not give satisfactory results at a height; and Lts. Freeland's and Black's developed some sort of ignition trouble."

Fortunately, matters improved a little and much good work was performed by No. 99 Sqn. as the mechanics grew to understand the shortcomings of the Puma. The experience was not cheaply bought: their average daily working hours were never fewer than fourteen.

One or two "home-made" modifications were contrived by the squadron in attempts to minimize the inadequacy of the D.H.9's engine. A pair of carburettors fitted with squadron-modified altitude controls were fitted to C.6210 and produced a worthwhile improvement in performance. The aircraft was flown by Lt. W. G. Stevenson and was regarded as the best machine in the squadron. In at least one case (that of C.6202) the replacement of the original small-diameter air-intake pipes to the carburettor by the 2½-in internal-diameter pipes which were later standardized effectively improved the aircraft's performance.

No. 99 Squadron was not alone in its misfortunes, and there can be no doubt that the same troubles were also experienced by the other units which were equipped with D.H.9s. Statistics for the Independent Force show that of all the D.H.9s which set out for enemy targets, one in every seven was obliged to return without reaching its objective.

One of the D.H.9's greater successes was the attack on Thionville railway station made by 12 machines from No. 99 Sqn. and six D.H.4s of No. 55 Sqn. on July 12th, 1918. Seven 230-lb, twenty 112-lb, eight 25-lb and two 40-lb phosphorus bombs were dropped; an ammunition train was twice hit; shell-laden trucks caught fire and exploded; shells stacked in sheds by the tracks also exploded; and two buildings housing small-arms ammunition and hand grenades caught fire and blew up. An enormous amount of damage was done, and the goods station was completely destroyed.

Enemy fighter opposition began to increase during the summer of 1918, and it became more and more imperative for the D.H.9s to hold their formations when attacked, in order to provide adequate defensive cross-fire from the observers' guns. That, in its turn, demanded unflagging performance from the engines.

A grim example of what could happen was provided by the events of July 31st, 1918. They are best described in the dispassionate words of the historian of No. 99 Sqn.:—

"On Wednesday the 31st, twelve machines, led by Capt. Taylor and Lt. Doidge, left for Mainz at 5.30 a.m. Three of these returned before crossing the Lines, Lt. Broadbent with a cracked cylinder head, and Lts. West and Richards with minor engine trouble. The remaining nine machines were attacked by forty hostile scouts in several strong formations in the neighbourhood of Saarburg. The co-operation and power of manœuvre of the enemy were much above the average. Their tactics were to engage in a general combat, six or more machines at a time manœuvring freely above the formation, whilst two or three machines concentrated on a single D.H.9 from below at very close range. Owing to the fact that the Albatros and Fokker scouts were approximately twenty miles per hour faster than the D.H.9s, these tactics were practicable, and proved very successful.

"Seeing that it would be impossible to reach Mainz in the face of such odds, Capt. Taylor decided to bomb Saarbrücken. Four D.H.9s had been shot down before this objective was reached, but the remaining five pilots dropped their bombs on the station and sidings. On the return journey, three more of the formation were put out of action, and it was probably due to the appearance of two formations of No. 104 Sqn., which had just crossed the Lines, that the remaining machines piloted by Capt. Taylor and Lt. Hewson, with Lts. Notley and Alsford as observers, were able to regain their aerodrome."

Of the fourteen officers who were lost in this action five were killed and the remainder made prisoners. It was not until August 15th that No. 99 Sqn. was restored to sufficient strength to make another attack. The unit joined with No. 104 Sqn. to attack Boulay aerodrome.

A week later the D.H.9s of No. 104 Sqn. were attacked by 40 enemy fighters while on the way to bomb Mannheim. Two of the D.H.9s were shot down before the target was reached, and five more fell on the return journey.

Maj-Gen. Trenchard's prophecy that the D.H.9 would be obsolete by June 1918 had proved to be correct. By the end of August he decided that it could no longer be regarded as a front-line operational type, and that the losses its continued use must incur did not justify sending the D.H.9 squadrons over the lines.

In his report on the work of the R.A.F. on the Western Front during October 1918, Maj-Gen. J. M. Salmond summed up the D.H.9's shortcomings in the following terms. Pointing out that the success of air operations depended upon the degree of air superiority attained, he said:—

"This is demonstrably true, at the present time, of D.H.9 Squadrons with 200 B.H.P. engines, for although this type of aeroplane has sufficient petrol and oil, to enable it to reach objectives 100 miles from the lines, its low ceiling, and inferior performance, oblige it to accept battle when, and where, the defending forces choose, with the practical result that raids tend to become restricted to those areas within which protection can be afforded by the daily offensive patrols of scout squadrons. . . ."

But there were no replacements for the D.H.9s until the war was nearly over, and they had to soldier on until the Armistice, not only with the units of the Independent Force but with many other squadrons.

(To be continued)

Assessing the Tu-104

"Flight" photograph

AS we have indicated in our leading article the visit to London of the Russian Tu-104 jet transport—almost the only occasion in peace-time upon which a virtually unknown aeroplane has been presented for the world's perusal—has inspired a remarkable series of comments and opinions, some sound, some contradictory and some ridiculous. Last week we published a first appraisal of this aeroplane; here we offer further conclusions. Notes on the interior appear on p. 401 and a special three-view drawing by D. I. Punnett will be found on p. 389.

IT is refreshing to study an aeroplane like the Tu-104, in which design influences have been not all-British, or all-American, but British, American, German and Russian. If one wished to be mean one could say it was a "poor man's jet-liner," for it is about as economical in design and manufacture as such an aeroplane could be. On the other hand it cannot be denied that to have brought such a machine to the point at which route-proving trials are taking place is no small achievement.

Russia has been collecting large-jet experience only since 1951 at the earliest. Most of her work in this field has, naturally enough, been military, and it is not therefore surprising to find that the Tu-104 owes much to an established bomber design.

Although the skin of the Tu-104 nose is of a different quality from that of the rest of the airframe it should not be inferred that the nose is, in fact, from a Badger production line. The transport has a much fatter fuselage (11ft) and full section is developed rapidly. It seems, therefore, that the nose and flight deck are merely based on the Badger design, but are not identical. The flight crew comprises two pilots (Capt. Starkov was in command on the London trip), navigator, radio officer and an engineer. A stewardess is also to be provided on Aeroflot services.

The first Tu-104 was publicly demonstrated at Tushino last July and more than one machine has since been flown throughout "all the Russias." It is believed that one has flown routes extending to Vladivostok, and other flights include Moscow-Khabarovsk (nine to ten hours) and Moscow-Novosibirsk non-stop (2,000 st.m). Although the Tu-104 is in production, few are believed to have been built so far. In spite of its bright finish there were signs that L-5400, which came to London, had flown many hours.

As a design the 104 has been described as "totally uneconomic" by a renowned British personality. This is probably an over-statement of the case, although there is no doubt that the engines (they have been described as M-209s) are no match for the best of the West in the matter of specific consumption. In the Badger they are thought to have a maximum rating of 18,000 lb. The civil engine is derated to 6,750 kg (14,890 lb), as we mentioned last week, and the aircraft took aboard at London some 5,100 Imp. gal of kerosine (the figure of 8,000 gal, or 60,000 lb, previously reported is the total capacity of the tanks). On a 3½-hour stage this appears excessive for this size of aircraft. Combustion is probably poorer than in the best British engines, if the smoke consequent upon opening up the engines at sea level (as Starkov did upon arriving at L.A.P.) is any guide.

Some people have said that 50 passengers on two turbojets is a bad idea. Frankly we cannot see why. It all depends on what engine is chosen; if it be an untried powerplant then the idea makes no sense at all, but if it is a rugged, reliable engine then two units should be cheaper and easier than four. The Tu-104 can fly quite well at full load on one, and asymmetric problems should be trivial. In any case, there is every reason to believe that this massive axial is, in fact, a very well proven engine, especially if it is derated to only 83 per cent of its military thrust. The 104 took aboard no water or water/methanol.

We have described the undercarriage as stalky. This probably stems from the bomber ancestry, for the Badger has a mid-mounted wing which makes a long undercarriage a necessity. The 104 gear is, in our opinion, not at all bad, and probably has a weight of some five per cent, assuming the maximum weight of the aircraft to be 120,000 lb. A comparison with the Valiant B.2 shows many points of similarity.

It is abundantly clear that the 104 is not a notably fast aeroplane; Mach 0.85 is certainly beyond it. For this reason it is evident that the considerable sweep angles have been a means to using thick surfaces; and the lower picture shows what we mean. Of course, a wing of this type greatly relieves the problems of finding space for fuel, and such items as flap jacks. The engines are cantilevered rearwards from the spar structure and one intake duct passes beneath the wing proper, while a second duct almost certainly goes through the spar webs.

There is no question that the Tu-104 is designed to a cabin pressure differential of at least five pounds per square inch. The use of oxygen for all aboard is only prudent at an early stage in the career of such a transport, and there is no doubt that Russia has been deeply impressed by our own experiences with pressure cabins and does not wish to run before she can walk. There was no evidence of fail-safe design from the exterior, apart from the use of three main spars in the wing, but it would not be reasonable to suppose that Russia has ignored any of the West's experience in this field.

To sum up, then: the Tu-104 is fairly fast, easy to fly, modest in its demands on airfields (both as regards runway length and pavement bending moment), cheap to build and maintain (in relation to its competitors), capacious and probably comfortable, and quite well developed. On the debit side, it is by no means as efficient on a cost-per-ton-mile basis as the West's jet transports promise to be, and it is also what might be described as "unsophisticated"—an overworked word, but one which does well to describe something which is rather dated in conception and conventional in execution. Yet there is no reason to doubt that the Tu-104 will do its Aeroflot job as well as could any other machine in the world. And this job, of course, includes propaganda as well as ton-miles-achieved.

W. T. G.

The upper photograph was secured from a Whirlwind of B.E.A. on the last day that the Tu-104 was at London. On the left is the machine in a nutshell; thick wing, stalky bogies, and large turbojets close alongside the fuselage. Also visible are a static discharge spike and de-icing air outlets, both of which were mentioned last week.

FAIL-SAFE AIRFRAME DESIGN

The Lockheed Philosophy: "Fail-safe" preferred to "Safe-life"

THIS paper, by J. F. McBrearty, chief structures engineer of the Lockheed Aircraft Corporation, is a discussion of the two principal approaches to the prevention of catastrophic aircraft structural fatigue —the "safe life" and the "fail-safe" methods. The author concludes that the safe life method is generally inadequate, and that the fail-safe method is practical and sound. The paper has been slightly abridged for reproduction in these pages.

UNTIL a few years ago it was the practice of airframe designers to proportion the aircraft structure so that it was strong enough to sustain certain ultimate design loads without failure and certain limit design loads without permanent set. Limit loads were generally the maximum loads expected in service and ultimate loads simply these limit loads multiplied by a safety factor, usually 1.5. A structure having strength for these discrete maximum loads had a tolerable service experience and fatigue failures were usually confined to places where there was abnormal vibration or some substantial detail of design.

More recently it became clear that an aircraft structure designed simply for strength could very well experience failure from repeated loads during its otherwise useful lifetime. This situation came about as a result of many factors, such as refined design to trim out excess weight; new materials with high "static" properties; higher daily utilization of aircraft; and a longer economic life. Failures occurred in spite of increased knowledge about stress concentrations, load statistics, and inspection methods. Designers, therefore, have frequently been obliged to provide additional structural material, over and above that required for maximum strength, to guard against fracture from repeated loads. This provision for fatigue has been a crude thing at best in view of the very great difficulty in predicting actual service loads and the great number of variables which affect the development of a fatigue crack.

The Comet accidents and the splendid investigations by the Royal Aircraft Establishment, coupled with certain other accidents and near-accidents from fatigue on aircraft throughout the world, have brought the whole subject of safety from catastrophic fatigue failure into very sharp focus.

Basically, two methods for preventing aircraft destruction from the effects of a fatigue crack present themselves. The first of these is known as the "safe-life" method and the other the "fail-safe" method.

In the safe-life method the expected loading history of the structure is estimated or measured, the structure is analysed or tested for these loads and a predicted or laboratory life determined. A safe life is then chosen which is this laboratory life divided by a safety factor to provide for test scatter or other variables not otherwise accounted for. The structure is then retired or replaced when this safe life is reached in service. There are many variants of this method, including determination of a "safe" stress in which the factor is applied to the stress rather than the life, or equipping the aircraft with recording instrumentation and retiring the structure when a predetermined history of loadings is reached, or periodically sampling the service structure to measure its residual life. Still another variation is found in fatigue-warning devices designed to give indication of the consumption of fatigue life.

All of these methods have one essential in common and that is that safety depends on a serious fatigue crack not occurring within a certain safe period of service. Fundamentally, the method is an analytical one because, although many of its steps may be based on tests, the crucial step of determining the safe life itself requires the analytical or arbitrary provision for many variables. Putting this another way the big question is:—

$$\text{Safe Life} = \frac{\text{Laboratory (or predicted or recorded) life}}{?}$$

On the determination of this ? factor hinges the adequacy of the safe-life method. If the approach is based on a laboratory test of the structure under repeated loads then the factor must account for the following: statistical variation in specimens; loads omitted in test; thermal effects; corrosion or time-dependent effects; repairs and service modifications; effects of high "one time" loads; and statistical variations in loading experiences.

There are undoubtedly many others. So what must the factor be? A scatter in life among laboratory specimens under controlled conditions of 3.0 is not uncommon. In the Comet tests the laboratory life of the fuselage was 2.4 times that of the Elba failure and 3.4 times that of the Naples, hence the factor could not logically be less than 3 or 4.

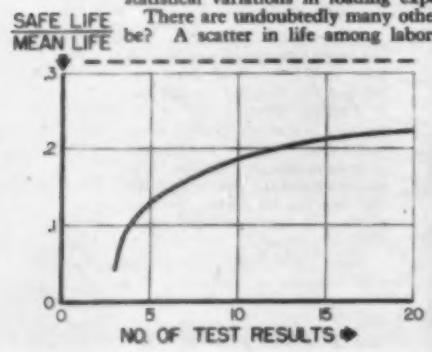


Fig. 1. The curve illustrated by Mr. Tye in the Second Barnwell Lecture. It may be deduced, with 90 per cent confidence, that the safe life would be no lower than shown in the curve.

Ref. 1 is to the Second Barnwell Lecture by Walter Tye. Fig. 1 and the following are reproduced from this source:—

"Statistical methods had been used by Kennedy to determine the additional allowance which should be made when information was limited to a few specimens. His calculations had been used to obtain the example illustrated in Fig. 1. Assuming the results of n tests, these indicated an average life represented by 1.0, and a scatter such that a life of 0.32 of average occurred once in 1,000 occasions. It was possible that the true mean could be lower or higher, and the scatter greater or less than the experimental values, and so there was no certainty that the safe life would be 0.32. Using statistical methods we could say with 90 per cent confidence (i.e., with nine chances out of ten of being right) the safe life indicated by the experimental results would be no lower than the curve shown in Fig. 1. Thus, if there were but six results from which a safe life of 0.32 were deduced, there was in fact a 1 in 10 chance that the life would be only 0.14.

"This very discouraging conclusion implied among other things that one could feel more confidence than was justified when a standardized degree of scatter was assumed, even when the experimental results supported the use of a standard value. It also meant that if the component indicated low scatter it would be unwise to accept this indication unless many results were available."

It is fairly obvious that we cannot test a great number of fuselages or wings or other components in order to pin down this effect accurately. Even so, there will remain at least the other variables in the list above. For example, acoustic vibrations from propeller, engine or jet efflux must be considered in either the test or in the factor chosen. Thermal stresses from changing temperature environment have their effect. Furthermore, it is known that specimens exhibit a longer lifetime when tested in a vacuum than when tested in air, indicating that the actual consumption of fatigue life is a stress-corrosion process and is thus time-dependent. Repairs and modifications are a practical consideration—a fuselage or wing could scarcely be retested under repeated loads each time a different window arrangement or a new door or such practical alteration occurred. The question of what to do about a severe gust experience or a hard landing that produces limit loads or even minor damage in service presents itself.

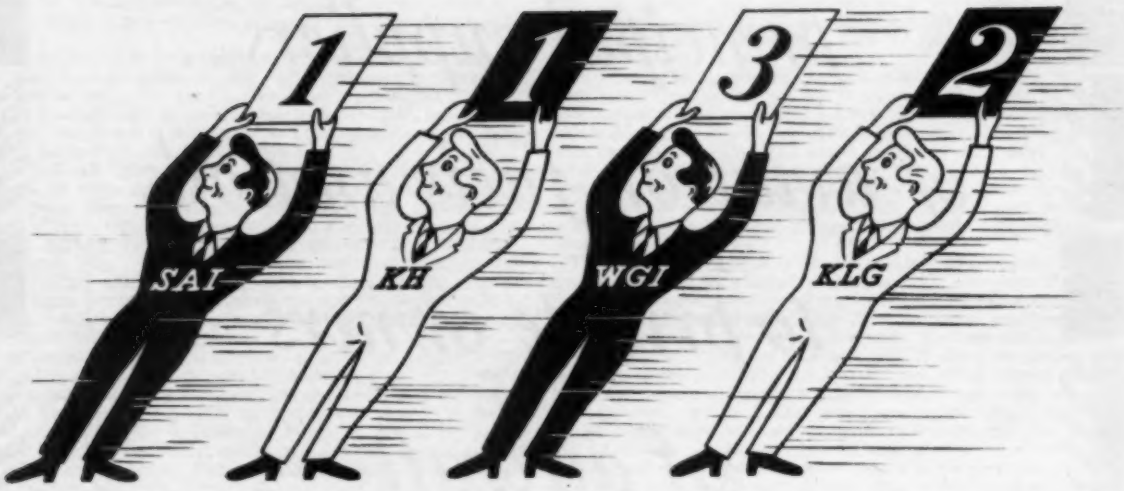
Must tests be rerun? The aviation Press has reported that the British feel that two structures must be tested, one statically and one in fatigue (rather than one structure for both tests), because the static test would invalidate the fatigue results. Thus the determination of the factor for relating laboratory life to a safe life is a most difficult process and, if safety is to depend on this factor, it must be chosen conservatively. The British feel the factor cannot safely be less than 9.0.

This same discussion applies and many of these same variables enter the problem when any of the variants of this basic approach are followed. For example, if an instrument is installed to record the actual stresses or accelerations experienced in the aircraft, this can minimize the error in determining the load history but cannot account for the statistical variation in material lifetime, time-dependent effects on the material, repairs, etc., and at the same time introduces the new variables of instrument response, reliability, and location.

A safe-life factor means that when the safe-life point is reached in service all the structures have life remaining and many structures which have not actually experienced the effects provided for will have consumed only a small fraction of their useful life and yet must be retired or replaced. This is waste, and yet is the price for safety under this method.

There is one final point which, in the author's opinion, is the *coup de grâce* for the safe-life concept. This is that, even assuming a safe life could be established to guard completely against catastrophic fatigue failure, there are other sources of structural damage, trivial in themselves, which cannot be permitted to destroy the aircraft. For example, the fuselage must not be destroyed by a turbine bucket or even a thrown propeller blade. Certainly a pressure cabin should not blow up if pierced by small-

ROUTINE STUFF . . .



Having flown the Fairey F.D.2 at speeds well over 1,000 m.p.h. for some time past, Mr. Peter Twiss was able to describe his record-breaking run* as 'Fairly routine stuff'.

Dealing with exacting flight conditions is also fairly routine stuff for the Smiths Group of Aviation Companies. The Kelvin Hughes and Smiths Instruments, K.L.G. equipment and Waymouth fuel gauges fitted in the F.D.2 are all from the standard range of equipment which has already proved itself in modern military and civil aircraft.

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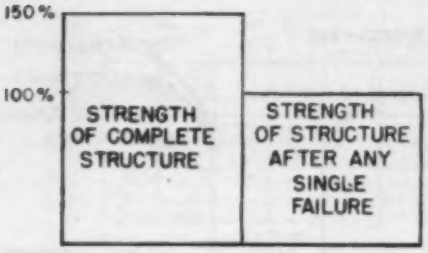


Fig. 2. The requirement for a fail-safe structure.

FAIL-SAFE AIRFRAME DESIGN . . .

arms fire from, say, a demented passenger. Similarly, a wing should not be destroyed by the presence of unnoticed ground damage from a loading truck or similar event.

Summing up, therefore, it is concluded that the safe-life method is impractical as a means *to provide safety from catastrophic failure*. In one form or another it must be used by the designer to provide a structure as free from fatigue-cracking as the state of the art, the economics of the aircraft and the manufacturer's reputation for a reliable product will allow. In this function, methods available are *not* inadequate. Lundberg (Ref. 2) has delineated much of the fatigue design field in the Wright Brothers Lecture for 1954. When viewed as a means to secure a generally serviceable structure, rather than a technique upon which lives depend, fatigue analyses and their complementary tests take on an altogether different significance. For such purposes the "safe life" becomes some reasonable average figure, not of profound importance, and the important quantities become the design stresses (or "allowables") which are subject to minor scatter and are comparatively easy to select, as brought out clearly by Shanley (Ref. 3).

Consequently, it is the author's conclusion that fatigue analyses and tests must be pursued with vigour, because the structure must indeed be as free from cracking as is practically possible; but this freedom from cracking cannot be guaranteed, indeed may never be, and thus it is inadequate and impractical as a means to provide safety from catastrophic failure.

The Fail-safe Method.—The method which appears to satisfy the need for a practical and sound safeguard against catastrophic failure from fatigue cracking or other reasonable damage is a "fail-safe" structure. By this is meant a structure which can carry an honourable service load even after one of its elements is ruptured. Fig. 2 illustrates this. The complete structure will sustain 150 per cent of maximum expected (limit design) loads as it does under present design philosophy and a fail-safe design is one which will sustain approximately limit loads with any one of its elements failed.

This design philosophy is not new, although its application to aircraft structure is new (see refs. 4, 5, 6, for example). It is based on the assumption that mechanical and human failures will occur and the airframe system must be prepared to cope with them. When this philosophy is examined it will be found that what measure of safety in aircraft operation has been achieved is due to a fail-safe philosophy. Multiple engines, dual controls, emergency systems, alternate airports, etc., are examples of this philosophy applied to similar problems.

In fact, the catastrophic fatigue failures that have occurred around the world can be traced to the absence of this feature. On the other hand, the serious failures which have occurred, and did not produce catastrophe, were certainly not the result of a safe-life approach but instead were due to the fact that those structures, whether intentionally or otherwise, did indeed fail safe. When a propeller blade failed and passed completely through a Constellation fuselage in pressurized flight at 20,000ft, it was a fail-safe ability that made this an incident rather than a catastrophe. Airline reports are full of cases of fractures from fatigue or other causes and the ability of the structure to fail safe under the circumstances has ensured that serious consequences did not ensue.

Thus the author concludes that the only practical answer to the safety problem generated by fatigue-cracking and accidental damage is a fail-safe structure. Much of the structure of today's airplanes is now fail safe (although perhaps not intentionally so) and it is believed that rather simple research, testing and analysis will show the way to a completely fail-safe airframe.

It is felt that supplementary stress analyses and laboratory tests of typical structural details can satisfy the fail-safe objective. Final fail-safe demonstrations of the structure may or may not be required, depending to a great extent on the thoroughness of the prior analyses and tests. Static strength is the property sought and not a nebulous and elusive life. The state of the art in static strength prediction and in laboratory testing is well developed and this can be exploited in fail-safe design. Much remains to be done, but the problems lend themselves to straightforward research and proven stress-analysis methods.

Developments in Fail-safe Airframe Design.—The following discussion covers the highlights of some fail-safe structural developments obtained at Lockheed Aircraft Corporation. More thorough treatment of certain aspects of this work is to be reported by other authors and is covered in unpublished reports (refs. 7 and 8). Work in this field naturally divides itself into three parts: material, stress level and detail design. Some results and observations on each of these aspects follow.

The Material.—Static tension tests on sheets of aluminium alloy with centrally located jeweller's-saw cuts of length normal to the load showed that 2024-T3 aluminium alloy carried more load than 7075-T6 before initial cracking occurred, a longer crack was survived before rupture, and a greater load was sustained at rupture.

Similar tests for several materials tested cross-grain showed that the absolute load-carrying strengths of severely cracked materials (3in crack length) arrange themselves roughly in this order of descending strength: 2024-T3, 2024-T81, 2024-T6, 7075-T6, 6061-T4.

In a series of large-scale fuselage-panel tests pressure cycles were repeated until complete failure occurred. To speed the test, water pressure was used until a crack started and thereafter air was employed. Tests on identical 7075-T6 and 2024-T3 panels were carried out. The 7075 panel started to crack after about 7,500 cycles of 5.7 lb/sq in and ruptured after a 6in crack developed at around 19,000 cycles. The 2024 panel, however, did not crack until about 95,000 cycles, many of which were as high as 8.5 lb/sq in to accelerate the test, and ruptured only when the crack had grown to 16in.

Tests on the strength of cracked sheet material at low temperatures showed that the strength of damaged 2024 sheet is unaffected by temperatures as low as —60 deg. F, while 7075 damaged sheet, weaker at room temperature than 2024, is further weakened by about 15 per cent at the low temperature. For comparison some data from similar tests on ship steel (ref. 9) show an enormous reduction in the strength of cracked material at low temperature.

Another significant property in a fail-safe design is the rate of crack growth. In Fig. 3 some data from tension fatigue tests of flat 9in strips have been plotted to show this property for 7075 and 2024 sheet. Note that this curve is plotted in *per cent* of total life and thus there is a greater fraction of life remaining (after perceptible cracking) in 2024 material than in 7075, at least under the conditions of these tests.

Summing up, there appears to be a considerable difference in the ability of different materials to fail-safe and, other things being equal, 2024 appears to require a greater static load to produce initial cracking, to sustain a greater crack before rupture, to support a greater static load at rupture, to be less affected by low temperatures, and to have a slower rate of crack growth under repeated stresses than 7075 sheet material.

The Stress Level.—The second variable under the engineer's control in creating a fail-safe design is the stress level. No other quantity has as profound an effect, not only in providing a fail-safe environment, but also in reducing susceptibility to fatigue. However, the weight of the structure is a direct function of the design stress level and thus the designer must choose a value which is just necessary and sufficient.

Fig. 4 summarizes some tension tests on panels composed of

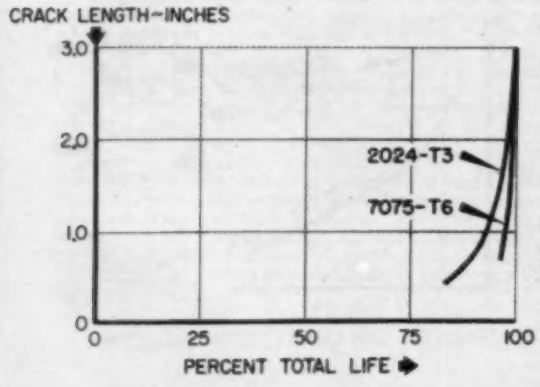
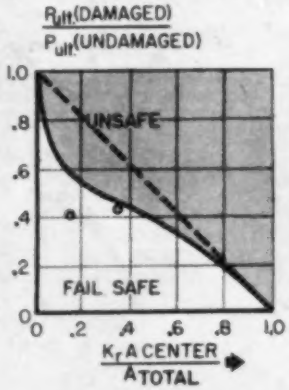


Fig. 3 (left). Crack growth plotted against time. The cyclic load was 1,200 to 12,000 lb/sq in.



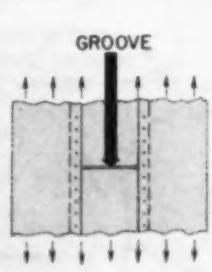


Fig. 4 (right). Tension tests on panels composed of three parallel sheets joined by riveting along their edges, as shown.

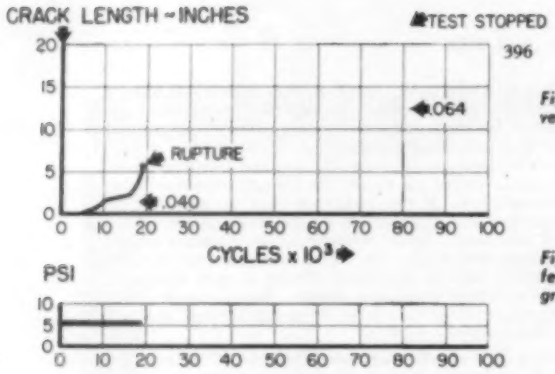


Fig. 5 (left). Crack length versus cycles (7075-T6 fuselage panel).

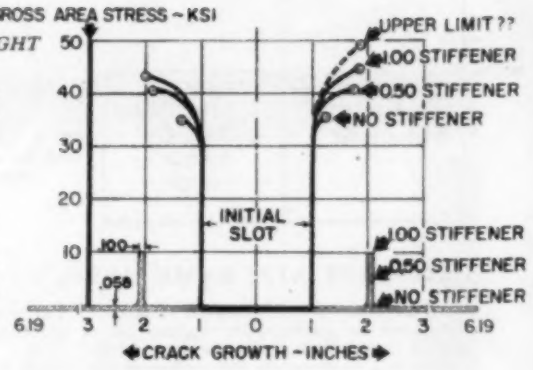


Fig. 6 (right). Effect of stiffener height on static crack growth and static strength.

FAIL-SAFE AIRFRAME DESIGN . . .

three parallel sheets joined by riveting along their edges as shown. The centre panels were grooved to varying depths to produce sudden tension failure of the centre panels at various load levels. At loads (or stresses) above the shaded boundary the adjacent panels broke when the centre panel failed, in other words did not fail safe. Below the shaded boundary, when the centre panel failed the added load was supported by its neighbours, it failed safe. The strain concentration caused by the local failure of the centre panel reduces the strength of the side panels below their nominal strength, which would simply be a diagonal straight line between the upper L.H. and lower R.H. corners of this diagram. The dynamic effect of the sudden failure will be discussed later.

Refs. 10 and 11 contain some published information on the stress-level boundary between explosive and gradual failure in pressurized cylinder tests which also indicates that a stress level can be chosen to preclude a destructive failure.

Fig. 5 is a plot of the Lockheed tests referred to earlier of full-scale fuselage pressure panels. These two panels were identical except for the skin gauge and the thinner panel ruptured under a pressure of 5.7 lb/sq in and a nominal hoop stress of 9,200 lb/sq in when the crack had grown to about 6in. The thicker panel (hoop stress of 5,750 lb/sq in) did not rupture even when the crack had been extended to about 22in. The test was stopped due to insufficient air supply. Absence of rupture in spite of such obvious damage is indeed a fail-safe structure.

Summing up, therefore, it appears that a properly chosen stress level can produce a fail-safe design in a multi-load-path structure and first indications are that this stress level is, as might be expected, below the nominal ultimate strength of the undamaged elements. A weight cost is thus indicated which research and design ingenuity must minimize.

The Detail Design.—A fail-safe structure must fundamentally be composed of multiple load paths or several elements such that when any one fails the structure suffers only in degree—unlike, say, a simple truss, which with any one member failed is no structure at all. This does not rule out structures with single large members provided these members are composed of discrete elements whose individual failure leaves a reasonable member strength and is sufficiently obvious to assure immediate detection.

Multiple elements present one form of crack or failure "stopper" and there is room for considerable design ingenuity to achieve a fail-safe structure by variations of this idea. Some of the design features under investigation at Lockheed are discussed briefly in the following paragraphs.

One idea which appeared to have merit was to exploit the fact that a round hole presents a lower stress-raiser than that at the end of a crack. In application, for example, the fuselage skin might be composed of two layers, an inner thick skin containing an array of holes and a thin outer layer. It was thought that a crack would advance from one hole to the next and for a given length of crack would provide more strength. Some simple tests were done on sheet aluminium having holes aligned with an initial narrow saw cut. Contrary to expectations it did "tear along the perforations" and the holes weakened rather than strengthened the initially damaged material. On the other hand, a simple stiffener attached with rivets through this same arrangement of holes perpendicular to the load increased the strength of the "cracked" sheet almost 20 per cent.

The behaviour of longitudinal stiffeners in integrally stiffened structure is illustrated in Fig. 6 which summarizes some simple tests on 7075 extruded panels 12¼in-wide machined as shown and tested in static tension with an initial narrow saw cut in the skin. It will be seen that the integrally stiffened arrangement develops more strength (higher fail-safe ability) than the flat panel, the stiffeners serving within limits as crack "stoppers."

Another design idea to provide a fail-safe characteristic, especially in a pressure cabin, consists of reinforcing strips which might be located at the fuselage rings and extend circumferentially to support hoop pressure loads in the event of skin failure. Wide (35in) panels of 2024-T3 alclad were tested in longitudinal tension with two spacings and two thicknesses of reinforcing strips. Each panel was tested with an initial lateral cut made with a jeweller's saw. While cracking commenced at about the same gross stress as the plain sheet, rupture did not occur until the failure had progressed beyond the reinforcing strips and for the same extent of damage developed at least 30 per cent more strength. Thus again the added elements served as crack or failure "stoppers" and provided a more efficient fail-safe arrangement from a weight standpoint.

Fig. 7 shows some further design features being considered and evaluated at Lockheed. Fig. 7a illustrates a method to provide a crack stopper for a wing shear web. In this arrangement the stiffener operates in service at a very low stress and can prevent complete loss of the shear web in the event of the lower spar cap [spar boom] rupturing. Fig. 7b illustrates the division of an integrally stiffened surface into segments proportioned and joined such that any segment can fail completely without major loss in total strength. Fig. 7c illustrates the pressure-cabin hoop strips referred to above, and Fig. 7d indicates how this idea might be extended to a grid arrangement to avoid joggling or shimming the stiffeners.

Summing up, it appears that much can be done toward achieving a fail-safe structure by application of design ingenuity to the problem and thus minimize the weight price that must be paid for this important feature.

Fail-Safe Testing Methods. While much can be done by straightforward stress-analysis of a structure containing assumed damage, until such time as our fund of knowledge about crack propagation, ductility, secondary effects, etc., is much greater than at present there will be considerable dependence on subjective testing. Furthermore, it is believed that even when stress-analysis methods for predicting the fail-safe capacity of aircraft structures are well established, and designers have acquired more experience in creating optimum arrangements, there will be a continuing need for fail-safe tests of the demonstration variety. Consequently, before leaving the subject of fail-safe structures, some observations on testing methods and techniques are appropriate.

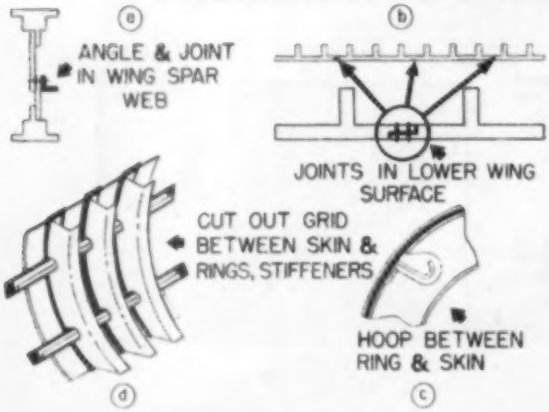


Fig. 7 (left). Some typical fail-safe structures.

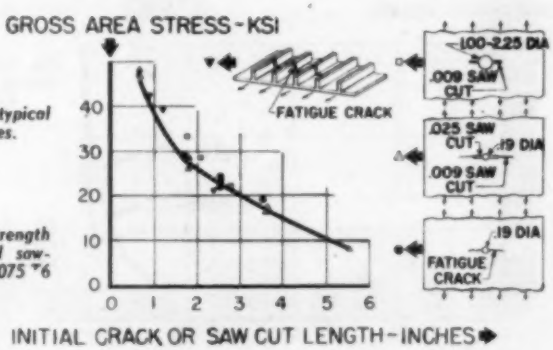


Fig. 8 (right). Static strength of fatigue-crack and saw-slotted panels (7075 T6 material).

FAIL-SAFE AIRFRAME DESIGN . . .

Of the many questions concerning techniques to be used in fail-safe structural tests this discussion will be confined to three: (1) Should air or water be used for pressure-cabin testing? (2) Must the dynamic effects of sudden failure be provided? (3) Does artificial damage simulate a crack?

Pressure-cabin Testing. Water-pressure testing of submerged cabins is advocated by some to provide safety, to minimize the scope of failure, and to accelerate pressure cycling in repeated load tests. The volume of compressed air in a large transport fuselage may amount to several million foot pounds of potential energy which, suddenly released due to major structural failure, can propel a large structure a long way. If air is used, safety precautions, such as rope netting, "stuffing" with some suitable material, or adequate barricades must be provided. Results observed to date do indeed indicate that a water test is safe, while there have been several cases of near accidents in air pressure tests.

Whether water tests do in fact minimize the scope of a failure is open to question. In the Comet tests, for example, the failure extended about 18ft in spite of the use of water pressure. In a test with air pressure on one panel, complete rupture from end to end occurred in spite of the fact that the air volume was less than one quarter of one per cent of total cabin volume. There is more than this much excess water volume in a complete pressure-cabin test, due to elastic distension, and this excess water volume must escape to relieve the stresses. It is believed that the strain energy in the structure determines the scope of the rupture and that the rupture takes place before any appreciable material (air or water) escapes, since the fracture advances at a high fraction of the speed of sound in the metal, which for aluminium is about 16,000ft/sec. A simple home experiment will illustrate this phenomenon. A toy balloon, distended with water and punctured, is destroyed as completely as it is when distended with air. In fact, rupture is so sudden that the eye can perceive the cylinder of water, intact, after departure from the balloon.

However, it is believed that in air tests there are "after effects" over and beyond the primary rupture due to the flow, which effects may or may not be of interest, depending on the purpose of the test. In pressure tests of large vessels the dynamic "overtravel" of the decompression results in a following suction which may cause crushing failures with air or water.

Water pressure testing, in comparison with the air method, definitely speeds cyclic testing and hence is rather commonly employed during the initial stages of such tests.

Thus the decision to use air or water hinges on the purpose of the test. There are four kinds of tests of large cabins where this question may arise:—

(a) **Pressure cabin fatigue-testing.** If full-scale tests are necessary water may be used to speed the tests and provide safety. The ultimate primary failure should be as complete as with air but without after-effects. However, the author questions the necessity of a full-scale cabin fatigue test in view of the discussion earlier in this paper. If a fail-safe structure is provided for safety, laboratory fatigue tests of fuselage components are better controlled and more economical.

(b) **Pressure cabin proof tests.** Type proof-tests could not be done with water since the fuselage must be a deliverable and saleable article. Water tests appear out of the question for production line leakage-testing.

(c) **Pressure cabin fail-safe tests and demonstrations.** Water could be used to determine scope of failure but would not reveal after-effects which may be important from a fail-safe standpoint. Air-testing is more convincing, realistic, and simpler, and safety can readily be provided by other means.

(d) **Pressure cabin ultimate or destruction static tests.** This is the kind of test for which there is, in the author's opinion, the best case for a water test owing to the hazard, to the principal interest being in the failure load itself, and to the desire to minimize after-effects for subsequent testing of the specimen.

Therefore, it is the author's conclusion that a large tank for testing pressure cabins under water is justifiable only when ultimate pressure static tests are required.

Dynamic Effects. The question of dynamic effects in sudden static failures is significant because it is the objective of a fail-safe design to provide sufficient strength not only after a failure or crack has occurred but *when it is formed.* If a sudden failure imposes a dynamic effect over and above the external load to be supported then the structure must possess this added increment of strength. Proposed Civil Air Regulations contain a 15 per cent additional factor for this effect, if not accounted for in an actual test. However, first indications are that this effect may be small. In tests such as those illustrated in Fig. 4 specimens developed the same strength whether tested under sudden rupture of the centre panel or tested statically with the centre panel initially severed, and fairly high-speed instrumentation was unable to detect any dynamic overstrain above the static strain.

It is believed that a dynamic effect can be significant only if there is a substantial momentum to be arrested by the surviving structure. In structural failures considered of reasonable scope for a fail-safe design the local velocities of movement may be large but the masses that move are small. For example, in the rupture of a single tension element in the lower surface of a fail-safe wing the added deflections are local and leave unaffected the bulk of the wing structure over the span. Since the overall deflections are a function of the integrated deformations over the entire span the beam deflections are suspected to be virtually unchanged. This effect must be established with certainty through further research, since it is important in tests whether the structure must be failed under load or not, as well as being important in design.

Crack Simulation. Perhaps the most difficult aspect of fail-safe structural design is the determination of the size or scope of the damage which should reasonably be provided for. In the case of discrete elements this decision is relatively simple, whereas in a fuselage skin it must for the present be based on practical judgment. This determination will not be discussed here but, whatever the extent of crack or damage to be considered, some fair simulation of it is necessary in tests.

One method that has been tried unsuccessfully is similar to an axe but tremendous forces are required, there is little control over the extent of the damage produced, and usually the device simply bounces off the structure without producing any damage at all.

Saw devices have been used with some success in producing controlled damage quickly and this is certainly a more attractive means than laborious cyclic testing which requires a great deal of time, is expensive, usurps facilities and, more often than not, fails to produce cracks where simulated damage is sought.

In an attempt to determine, however, whether a saw cut of a given length produces an equivalent reduction in static strength as a fatigue crack of the same length, a series of simple specimens were tested in tension. These specimens consisted of an assortment of fatigue-cracked and artificially damaged (saw cut) pieces. The static strengths of these specimens are plotted against length of fatigue crack or slot in Fig. 8. It will be seen that, in the case of these specimens at least, it makes no difference in static strength whether the damage is a narrow saw cut or a fatigue crack of the same length.

Further work is contemplated to improve these techniques but it appears that fatigue cracks can be quite faithfully simulated in simple fashion for fail-safe static testing.

Conclusions. The following conclusions appear warranted to the author on the basis of the foregoing discussion and the laboratory observations obtained thus far:

(1) The safe-life method in any of its forms is impractical as a means to prevent catastrophic failure from fatigue, and inadequate to prevent catastrophic failure from other reasonable causes.

(2) The fail-safe method of structural design is a practical and sound means to provide reasonable safety against complete failure from fatigue or other sources of damage.

(3) From the fail-safe standpoint 2024 aluminium alloy is superior to 7075 aluminium alloy.

(4) For a given crack or damage the stress level in the undamaged elements is below the ultimate strength of the material, as expected, but the indicated weight penalty can be minimized by suitable design practices.

(5) Water testing of submerged pressure cabins may be desirable for ultimate strength testing when required, or for fatigue-testing when necessary, but is undesirable for fail-safe tests, and impractical for proof tests.

(6) Dynamic effects in fail-safe tests appear to be small.

(7) Fatigue cracks can be simply and faithfully simulated in fail-safe tests and demonstrations.

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TWO CYLINDERS TO LE MANS

A Slow but Almost-sure Cross-channel Flight by Aeronca 100

THIS article, written by a former owner of Aeronca G-AEVS, Mr. M. J. Dible, describes a flight made in this machine from Denham to Le Mans last year. Of general interest to all pilots, it will prove particularly revealing to those who are not accustomed, in powered aircraft, to using thermals or cliff-lift, or making-good groundspeeds of 30 m.p.h. and being overtaken by trains.

The aircraft in the story.

"YES, . . . but I would like to have the C. of A. in time to go to Le Mans." In the silence that followed, the engineer looked as if he'd "met 'em before"; and the A.R.B. surveyor looked as if he wished I hadn't said that. The idea was to fly to Le Mans in my Aeronca G-AEVS for the 24-hour Race. Why not? Napoleon had walked to Moscow and back, so why shouldn't I fly an Aeronca to Le Mans? Aeroncas had done much better than that, and a more patient owner had flown to South Africa—even if he did have to fit high compression pistons before his aircraft could be coaxed into the air after a forced landing at more-than-average altitude.

I had completed the C. of A. overhaul myself, advised by the local engineer and visited by an endless stream of club members who would wander into the hangar, offer advice, and then ask for a swing on some aircraft on the other side of the field. The mighty 36 h.p. Aeronca engine had been overhauled; the fuselage scraped off and resprayed a bright distinctive red with grey lettering (which could be identified at an embarrassing height). Now there remained only the long-awaited rubber-stamp on the C. of A. which would once again permit me to nauseate the local sky and—perhaps—some of that fabulous land beyond the channel.

At last the great Friday dawned and I spent the day casting furtive and anxious glances at the weather, until Richard and I slipped away early from work and substituted the car for the Aeronca in the hangar at Denham. With our kit and borrowed Mae Wests we were somewhat over-weight (neither of us are fairies), and so a maximum take-off run was essential. This evoked much wrath from the groundsman as we taxied across the cricket field with this idea in mind. Running into the long grass of the aerodrome produced a feeling of deceleration, and for some time I was of two minds whether to abandon the take-off. However, all went well and we were soon climbing at a negligible rate, on a course calculated to take us round to the north of London.

In the lee of the city the visibility deteriorated and rain began, cracking against the windscreen with a noise which gave me to wondering if I had made a mistake over the thickness of Perspex I had used to renew it. Kent looked wet, with low scattered clouds spreading their contents over the countryside; and, as we sat huddled in the small cockpit, the prospects of reaching France that evening became gloomier.

At last Lympne was in sight and after a circuit which seemed to take years we tucked in behind a Freighter and landed. Taxying the Aeronca is easier with the door open to give more elbow-room, and it does not require much wind before the passenger needs to be out holding the wing-tip. I finally arrived in the Customs area, with the tailskid on my shoulder, and parked her alongside the towering Freighter.

Formalities were rushed with the maximum co-operation from all concerned. Air Traffic said it was a fine sunny evening in France, and that the aerodrome at Le Touquet closed at 2045; with luck we could just make it. After take-off, good resolutions about having 5,000ft before approaching the channel went by the board and the waves were lapping the shore below before we had 800ft. I compromised between flogging the engine and gaining height, and settled down at 1,200ft. Before us lay the unforgettable sight of the French coast bathed in the sun of a June evening, and our worries about the weather vanished.

It is incredible the variety of noises an engine will make over water, and ours was no exception; but gradually as the coast drew nearer and we began to cut the corner, turning south, the note sounded more confident. Or was it me?

Over Boulogne we had the mortification of being passed by a train, but a quick calculation on E.T.A. showed that we could just beat the deadline. And so it was: Le Touquet came into view and a persistent "green" operator from the tower urged us to cut the circuit and land quickly so that he could shut up and go home. The sudden scraping of the tailskid on the runway announced that the first day's operations were complete, bar the celebration.

Saturday dawned misty and raining, but I was in no hurry to get up—we had other troubles. Tardily we made our way to the airport, depressed and damp, only to be greeted by a Proctor crew who jovially announced that conditions were QBI and we could not go. About midday, when things seemed worse than ever, we were suddenly cleared for Deauville, and with some trepidation squeezed into the Aeronca, for by now low cloud and rain were drifting up from the south-west, cutting visibility to an uncomfortable degree. We decide that perhaps Air Traffic knew more than we had gathered from a sketchy translation and that, at a mere 60 m.p.h. hugging the coast, we could have a look-see. It turned out that this was the last of a warm front.

We had an uncomfortable moment on take-off, caused by turbulence over the trees. About two-thirds of the way down the runway we cleared the tree-level with a sigh of relief, only to experience that contraction in the throat as we suddenly lost 50ft. The trees were now very close, with no sign of the horizon beyond; the little twin Aeronca engine was struggling mightily, thrusting every one of its 36 horses into the air; while I bent the throttle against its stop and tried to maintain a compromise between altitude and the wildly dancing A.S.I. needle. We cleared.

Soon the celebrations of the previous evening began to take their toll. Windows were opened and shut, pills and sweets were sucked . . . The flight plan was changed slightly to follow the coast a mile or so off the shore, sacrificing distance for comfort, and we were well toward Le Havre before feeling fit enough to tackle the rougher air and cut across the land for Deauville. Progress was slow due to headwinds and it took *Veronica* two hours ten minutes to cover the 112 miles, making touch-down—or arrival, one wheel and a wing-tip—around 2.30 p.m.

Two rather frail aviators sat down to a light salad lunch provided by the excellent restaurant and restored the will to press on; but the suggestion of a little wine was ill received.

A general speculation on the proposed flight-plan showed that to reach Le Mans with the present wind (a headwind of 30 m.p.h. at 2,000ft) was an improbability, and success would depend on the wind strength falling off as evening approached.

With every teaspoonful of our 6¼ gallons of petrol in the tank (and the last quarter of a gallon in my shoes) we began the long downwind taxi to the end of the runway, with Richard manning the wingtip. At last, having lost and used an embarrassing quantity of our precious fuel, we were ready to take off, but, on turning into the wind to run up, all I could get was 1,800 r.p.m. and smoke-rings. The engine sounded very sick, and my heart sank as visions loomed large of the difficulties ahead with an unserviceable aircraft stranded in France. Solemnly we taxied back and stopped the motor. An enthusiastic French mechanic appeared with boxes of vintage plugs and spanners, and his enthusiasm reached unbounded heights when he discovered that one of my plugs had a cracked insulator. This I knew, and I also knew that the crack was immaterial, but it did not make it any easier to dissuade him. The oil thermometer showed the engine to be hotter than I had ever known it, and after another

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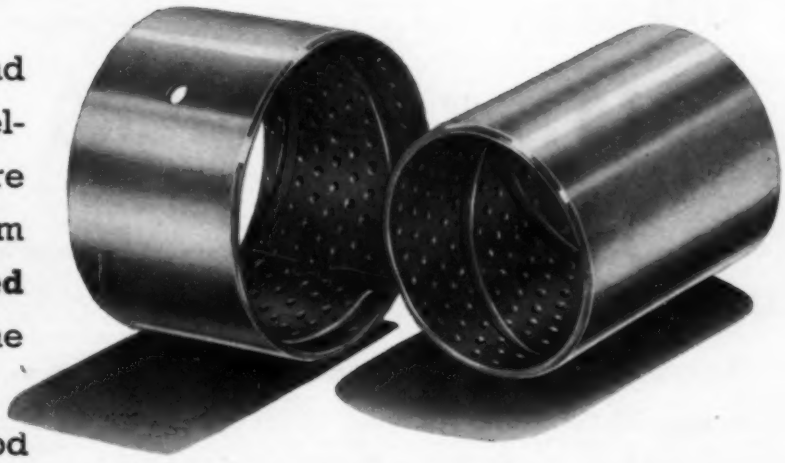

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ICI

TWO CYLINDERS TO LE MANS . . .

run, when all seemed well, I concluded that the long downwind taxi had caused overheating.

We topped up with petrol, gave the exhaust-valve stems a shot of oil for luck and, while Richard stumbled to keep up with the wing-tip, I taxied as fast as I dared to the runway. This time the engine was in good form and we took off.

The next leg was the most interesting of the trip for the navigator, who had to keep a careful check of groundspeed tendencies and fuel consumption. *Veronica* used 2½ gallons an hour, but the last two gallons in the tank did not record on the gauge, and so graphs were drawn to enable us to consume a safe proportion of this on a time basis. I had carefully calibrated the gauge, a foolproof cork-and-wire device, to enable us to cope with such an emergency; I was confident of its indications and noted readings at regular intervals. An initial groundspeed of 30 m.p.h. encouraged us to fly carefully for range and at heights calculated to cheat the wind. In such a slow machine as the Aeronca it is incredible how great an increase in range can be obtained by careful use of flying controls and throttle. Even thermals were used to gain height and later converted into speed at reduced throttle-setting.

Gradually our groundspeed increased as we approached Alençon, the only possible diversion field, but the final decision as to whether we could safely make Le Mans could not be made until Alençon lay directly below. The answer was in the affirmative—even though the fuel gauge was almost on its stop.

Le Mans came up at about 7 p.m. Looking down on the race we could hear the noise of the cars above that of our own engine. A quick circuit, positioning ourselves where we hoped to be seen by half-expecting friends in the covered stand, and we landed, late but triumphant. Taxying in, we were greeted by such comment as "Formidable! . . . C'est formidable!"

A peep into the tank confirmed our calculations. Three-quarters of a gallon, or about 20 minutes to dead cut. In considerations of this sort one must take into account the type of machine. The Aeronca could touch down at 28 m.p.h. with the brakes on and stop in 12 yards; besides, there were plenty of garages along the road!

It is not the purpose of this article to describe the next twenty-one hours, but in the early dawn I actually succeeded in getting some sleep in the cramped cockpit. After the race we settled down to our long take-off run, this time on soft sandy ground with a runway well out of wind, but somehow we were airborne again despite the fact that full throttle—and even some "bumping scramble" tactics by the occupants—was required to get *Veronica* moving at all.

Flying north, and passed by many others on their way home, we noticed the weather worsening, with frequent rain-showers and low cloud. Deauville was again the target but as we approached cloud settled on the hill. However, we were just in time to squeeze in, followed closely by a Proctor which had abandoned the direct flight home after a few miles out over the Channel. We joined forces with the Proctor crew and spent a pleasant evening, concluding with a quiet visit to the Casino with the intention of defraying part of our expenses but, of course, merely adding to them.

The following day saw us stroking our way home in easy stages with lunch at Le Touquet. Flying along the coast I found it possible to increase our speed by 5 m.p.h. for the same power setting, using the lift from the onshore wind over the cliffs. Flying an Aeronca seems in many ways more akin to gliding.

At Lympne the take-off was even more prolonged and difficult owing to rough rising ground and lack of wind, but a carefully selected gap in the trees must have served many similar take-offs before. Our progress homeward was rather too easy-going, due to lengthy meal-stops, but it was with a great sense of satisfaction that we manœuvred *Veronica* back into the hangar at Denham after her three-day absence and got out the car. Have you ever noticed how smooth a car feels after flying?

THE INDUSTRY

Electronic Computor Service

THE English Electric Co., Ltd., has opened a new computing service centre in its London office at Marconi House, Strand, W.C.2. The centre is an extension of the Nelson Research Laboratories' work at Stafford, where computing on the company's Deuce (described in *Flight* of April 15th, 1955), the most powerful machine of its type in Europe, is already done for members of the English Electric Group and outside organizations.

The London machine is manned by a team of mathematicians specializing in the application of high-speed digital computing to problems in aircraft development, and all branches of mechanical engineering and communications, civil engineering and commerce. The service has behind it an extensive library of programmes which have been previously prepared for the solution of a wide range of problems. Computing problems in the development of the P.1 were carried out on the Deuce.

Electro-Hydraulics Expansion

A NEW laboratory devoted to the design, development and testing of Electro-Hydraulics products for the aircraft industry was officially opened on March 23rd at Warrington by Mr. Reginald Maudling, M.P., Minister of Supply. Introducing the Minister, Mr. C. W. Sharp, managing director of Electro-Hydraulics, Ltd., recalled that the company had been associated with the aircraft industry since 1939. It had been decided some 2½ years ago to extend the firm's aeronautical facilities, he said, and the new laboratory building was the heart of a long-term expansion now envisaged.

At a luncheon following the opening ceremony and attended by representatives of the industry and the Ministry of Supply, the health of the guests was proposed by Mr. A. G. B. Owen, C.B.E., chairman of Electro-Hydraulics, Ltd., and the Owen group of companies, and the reply was voiced by the Minister. Proposing a toast to the aircraft industry, Mr. C. B. V. Neilson, technical director, said that the company's drop-testing machine, now housed in the new laboratory, was probably the most advanced equipment of its kind in the world. "It is able to spin up the landing-gear wheels in order to represent drag loads, the landing table is shot sideways by a very powerful hydro-pneumatic mechanism to reproduce side-loads, and the actual ground reactions due to vertical, drag and side-loads are directly measured by means of strain-gauge links in addition to the usual electronic accelerometers."

Turning from the company's undercarriage work to its progress in other hydraulic fields, Mr. Neilson said, "The highest refinement of the hydraulic system is the electro-hydraulic servo-mechanism. . . . Our engineers are applying servos not only in connection with aircraft and guided weapons, but also in the control of machine tools for the aircraft industry." In the attack on high temperatures, he disclosed, the company had already had pneumatic actuators working at 400 deg C, and their electrically operated control valves were effective and reliable in operation at 300 deg C. A reply to the toast was made by Mr. R. S. Stafford, C.B.E., technical director of Handley Page, Ltd.

Australian Bristol Appointment

THE appointment is announced of G/C. E. A. Whiteley, C.B.E., D.F.C., A.F.R.Ae.S., as a director and general manager of the Bristol Aeroplane Co. (Australia), Pty., Ltd., in succession to the late Mr. C. H. Tucker. An Australian, G/C. Whiteley saw operational service with the R.A.F. in 1940-41 as commander of a photographic reconnaissance squadron in Malta and later in command of various operational wings in Burma; at the end of the war he was Group Captain Operations at H.Q. Air Command, South East Asia. After the war he obtained a commercial pilot's licence and navigator's licence and in 1948-49 served in the Directorate of Navigation at the Air Ministry. In 1949-51 he was in America under the exchange scheme and in 1952 was again in S.E. Asia, this time as Director of Plans under C-in-C. Far East Air Force. Last year he returned to England to take over the command of R.A.F. Station Tangmere.

Instrumental Development Post

THE firm of Measuring Instruments (Pullin), Ltd., announce the appointment of Mr. W. T. Shelton, A.M.I.E.E., as chief development engineer at their Electrin Works, Winchester Street, London, W.3. M.I.P.'s current development programme includes a complete range of hermetically-sealed instruments to R.C.S. specifications.

Mr. Shelton joined M.I.P. in January from the Rheostatic Co., Ltd. From 1949 to 1955, he was project engineer with S. Smith and Sons (England), Ltd. Aged 35, he received his technical education at the South-East London and Hendon Technical Colleges, and during the war served with the Royal Fusiliers and R.E.M.E. for two years; during part of this period he was an instructor at the Telecommunication Engineering Wing, Aborfield.

(*"Industry" news continued overleaf*)

THE INDUSTRY . . .

IN BRIEF

High Duty Alloys, Ltd., announce that they have acquired, as from March 31st, the gravity and pressure-diecasting foundries operated by Renfrew Foundries, Ltd.

* * *

As from April 1st, the research and development activities of Export Packing Service, Ltd., have been under control of a subsidiary company known as E.P.S. (Research and Development), Ltd. Mr. D. Gonda has been appointed its technical director; the other directors are Messrs. R. C. Boucher (managing), E. C. Boucher and E. V. Norcock.

* * *

The Supermarine Works of Vickers-Armstrongs (Aircraft), Ltd., announce that they are to transfer their entire design, technical and drawing office sections from Hursley Park, near Winchester, to their main factory at South Marston, Wiltshire, which now becomes the central design and manufacturing establishment of Supermarine. The transfer will take place gradually over the next two years.

* * *

On March 31st, Louis Newmark, Ltd., was placed in members' voluntary liquidation, following which the whole of the assets, liabilities and undertakings were transferred to the parent company, Louis Newmark (Holdings), Ltd., which has changed its name to Louis Newmark, Ltd., and is carrying on the business with the same management and personnel, and in the same manner as hitherto. The company's products include aircraft autostabilization and autopilot equipment, general gyroscopic instruments and navigational aids.

* * *

In a recent article on the aircraft design work of E. G. Irwin and Partners, Ltd., it should have been made clear that the chief stressman is Mr. D. J. Farmer and chief draughtsman Mr. J. Cutler.

* * *

To avoid possible confusion with another firm, High Precision Engineering, Ltd., of Southampton (who took over the business of Weir Precision Engineering, Ltd., last autumn) have changed their name to Vero Precision Engineering, Ltd.

* * *

Recently appointed as U.K. and European representative of the Aviation Industries Association of New Zealand is Mr. Beverley J. Snook, aviation consultant, of 352-354 Kilburn High Road, London, N.W.6. Mr. Snook, well known as an air-racing pilot in this country, will provide liaison between the association (and member operators) and European manufacturers interested in topdressing aircraft, and will evaluate new equipment as and when it is produced.

CORRESPONDENCE

The Editor of "Flight" does not hold himself responsible for the views expressed by correspondents in these columns; the names and addresses of the writers, not necessarily for publication, must in all cases accompany letters.

Filling the Trooping Gap

WOULD it not be a wonderfully cheap and swift way of re-equipping Transport Command to re-engine the Handley Page Hermes and the Canadair Argonaut with the latest marks of Rolls-Royce Darts and the Airspeed Elizabethan with two Napier Elands?

Surplus Argonauts now in Canada could be bought in part exchange for more Vickers Viscounts; with such a fleet it is possible that all troop transport could be by air instead of a large part having to go by sea as at present.

I cannot understand a naval power like Britain allowing any troops to go by sea. Troopships need a much larger escort of warships than any other convoy; for this reason they must be a constant source of anxiety to naval staffs, and cause a serious drain of warship strength from more important naval operations.

It is also a very unpleasant thought that, while a Soviet security general arrives at London Airport in one of the largest and most up-to-date airliners in the world, British troops are still leaving Britain in piston-engined airliners of ancient vintage.

Sidcup, Kent. A. G. WILSON.

"Constant Speed" Flashback

WITHOUT wishing in any way to detract from the magnificent achievement of de Havilland Propellers, Ltd., as portrayed in your article *Enterprise in Airscrews*, I would like to correct one misconception which has appeared several times in your pages in articles of a similar nature, and that is in regard to the constant-speed modification. During those days I had the honour to serve with No. 92(F) Squadron. In June 1940 I was one of a party of six fitters detached to Hornchurch to carry out the constant-speed mod. on our own squadron Spitfires, which were flown in daily from Pembrey, where the squadron was resting. In 23 hectic days we completed 21 aircraft. Apart from initial guidance by a D.H. representative we were otherwise unaided, and as far as I know, the other squadrons then at Hornchurch (Nos. 65, 74, 54) carried out the job in a similar manner.

Wimborne, Dorset. A. G. WATTS.

Veteran Skymaster

THE recent correspondence in your columns on the early Constellations prompts me to write concerning a much-travelled Skymaster. The aircraft concerned bears the constructor's number 3094 and was, initially, serialled 41-37303 in the U.S.A.A.F. The Netherlands Government Air Transport Service then took over the machine with the serial number NL.300 and the enclosed photograph [a night scene, not very amenable to reproduction—Ed.] shows it in this guise at Almaza airport, Cairo, during 1943. With the liberation of the Netherlands the aircraft was civilianized for K.L.M. service and registered PH-TAB.

In 1947, with three other similar aircraft, it became one of the few Skymasters ever to appear on the British civil register, when it was purchased by Skyways, Ltd., and bore the letters G-AJPO. Their life in England, however, was short-lived, and the four machines went to Air France, 3094 becoming F-BELQ.

I do not know how long it resided in France, but this machine eventually found its way to the Far East and was registered to Air Viet-Nam as F-VNAN.

It would be interesting to hear if any other readers know of further details concerning this aircraft. It has probably now obtained a further registration with the allocation of 3W as the international registration of that country.

H.Q. 2nd T.A.F. D. F. GILPIN, Sgt.

The Short Sperrin

ON page 282 of your issue for March 16th a small error is to be found under the heading "Costs in Question" [the summary of Sir Frank Tribe's report]. It is stated that the second prototype Short Sperrin was used as a flying testbed for the D.H. Gyron engine. This is, of course, incorrect; the first Sperrin, VX158, is the aircraft fitted with the Gyron. The second Sperrin, VX161, is still at Farnborough. A. E. ADAMS.

Waltham Abbey, Essex.

FORTHCOMING EVENTS

Apr. 6. R.Ae.S. Main Lecture: "Problems in Production and use of Modern Light Alloys," by G. Forrest, B.Sc.(Eng.), A.F.R.Ae.S. (at Belfast).
Apr. 6. British Interplanetary Society (Harrogate): "Speculations on Extra-terrestrial Life," by S. S. Kind.
Apr. 7. British Interplanetary Society: "Power Supplies and Telemetry for Instrument-carrying Artificial Satellites," by J. Foley, B.Sc., F.R.Ae.S., Grad.I.Mech.E., E. White and R. Wilkins.
Apr. 12. R.Ae.S. Section Discussion: "Aircraft Interior Layout."
Apr. 13. Helicopter Association: "Aerodynamic Aspects of Helicopter Design," by H. Roberts, Ph.D., B.Sc., D.I.C., A.F.R.Ae.S., A.M.I.Mech.E.
Apr. 14. Surrey Gliding Club: Annual General Meeting.
Apr. 14. London Gliding Club: Annual Dinner Dance.
Apr. 14. British Interplanetary Society (Birmingham): "Astronautics Today," by R. B. Beard, Grad.I.Mech.E., Grad.I.Prod.E.
Apr. 17. R.Ae.S.: Section Lecture: "Investigation of Aircraft Accidents," by E. L. Ripley, O.B.E.
Apr. 18. Institute of Navigation: "Relative Movement and the Collision Problem." An analysis by some of the technical committee members.
Apr. 18. R.Ae.S. Graduates and Students Section: "Gas Turbines—Propeller or Jet," by R. M. Fitzgerald.
Apr. 19. R.Ae.S.: Main Lecture: "High Speed Experimental Test Flying," by Lt-Col. Charles E. Yeager, U.S.A.F.

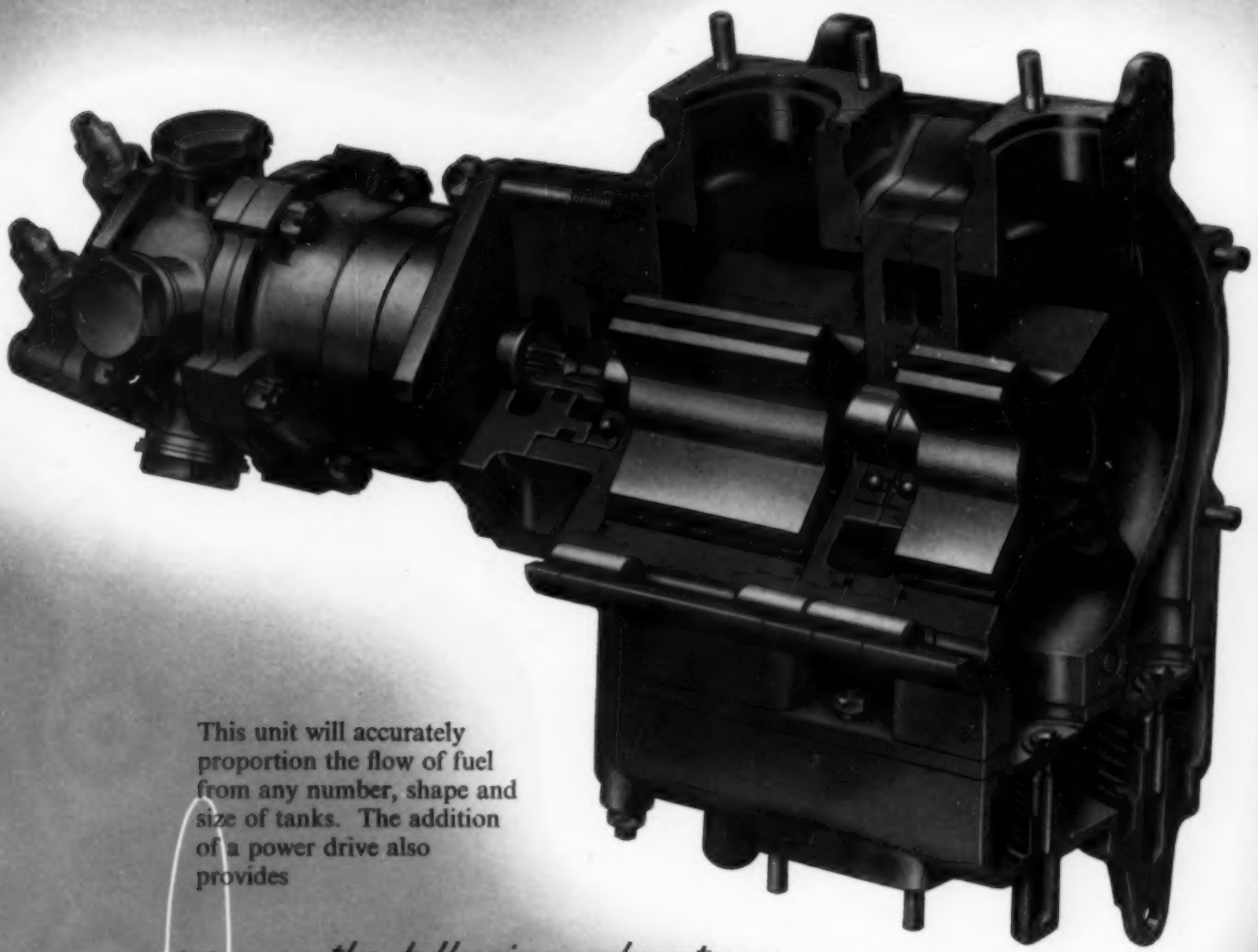
R.Ae.S. Branch Fixtures (to April 19th):—

Apr. 9, *Halton*, film, "We Saw It Happen." Apr. 10, *Bristol*, "Titanium—a Survey," By Maj. P. J. Teed. Apr. 11, *Glasgow*, film and A.G.M. Apr. 13, *Birmingham*, "Prop-Jets in the Navy," by W. H. Lindsey. Apr. 14, *Southampton*, Annual Dance. Apr. 16, *Halton*, Brains Trust. Apr. 18, *Coventry*, A.G.M. and films; *Preston*, A.G.M. and film show; *Southampton*, "Full-Scale Layout," by J. W. Earle. Apr. 19, *Cheltenham*, A.G.M. and film; *Reading and District*, A.G.M. and film show.

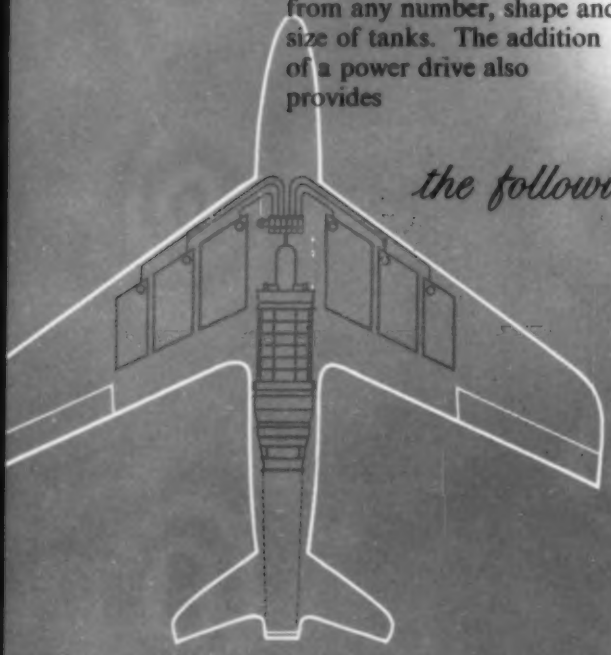
POWERED PROPORTIONER

Flight, 6 April, 1956

Rotol fuel flow proportioner with hydraulic motor drive



This unit will accurately proportion the flow of fuel from any number, shape and size of tanks. The addition of a power drive also provides



the following advantages

- An alternative source of fuel pressure in emergency cases.
- Additional fuel pressure at little extra cost in weight.
- Use as a backing pump providing engine pump pre-pressure.
- Proportionate refuelling at high flight refuelling rates.
- Any desired fuel pressure rise by the choice of suitable motor.

ROTOL

GLOUCESTER · ENGLAND

Redux — the proven adhesive

De Havilland Dove VH-AWD, belonging to Western Australian Airlines, has completed over 17,000 hours' flying—the highest total attained by any aircraft of this type. Like all other Doves it is 'Redux'-bonded and it is a good example of what we mean by 'Redux'—the *proven* adhesive.

In the last ten years, 'Redux' has been used for bonding metal structures in more than forty different machines, ranging from airliners to guided missiles and often operating under extremes of heat and cold. It has saved weight, lowered production costs, increased resistance to fatigue—these are known advantages of adhesive bonding which are influencing the design of new machines.

But only one adhesive has been tested under all kinds of operating conditions, specified by leading aircraft makers throughout the world, employed for load-bearing structures in ten years of flying. Adhesive bonding means 'Redux' — the *proven* adhesive.

There is a wealth of literature on the 'Redux' bonding process. Much of it is of absorbing interest as well as significance to the designer and production engineer concerned with structures of the future. May we send you some examples?

'Redux' ADHESIVES *for metal aircraft structures*

'Redux' is a registered trade name

Aero Research Limited, *A Ciba Company* *Duxford, Cambridge. Telephone: Sawston 187.*

SBAC

AP 264/113

Some of the Victor's thunder at Handley Page, Radlett, last week (p. 377) was stolen by the Herald prototype, which took time off from its development trials at Woodley to be on view.

CIVIL AVIATION

INSIDE THE Tu-104

FEW people were permitted to look inside the Tu-104 during the six days it was parked, cordoned off, at London Airport Central. From the comments of the officially privileged few who were so fortunate, however, it is possible to present a fair picture of the airliner's interior. The general impression was that finish and workmanship were first-rate, but that the styling was somewhat rococo—a characteristic of Russian interior architecture generally. Accommodation was arranged for 50, there being one main cabin aft for 28, and four small V.I.P. pullman-type saloons. One of these, next to the main cabin, had eight seats; the next two each had four seats on the starboard side, with a pantry to port. The forward saloon was a six-seater. Chairs in the 28-seat main cabin were double units—adjustable, but not fully reclining—with broad armrests and at a generous pitch of 42in. There was no dominant colour scheme, but (again typically Russian) much woodwork, including dark polished frames around each window. Cabin width (more than 11ft) was generous, and there seemed to be plenty of space for at least 70 tourist passengers. Two lavatories, accessible *via* separate washrooms, were right aft —as in the Comet—against the pressure bulkhead. Crew accommodation was for six—two pilots, a navigator, a radio officer, a flight engineer, and a stewardess.

THE BRITANNIA DEMONSTRATED

SOME six hundred airline executives, technicians and engineers —mostly representatives of Lufthansa and S.A.S.—flew in the Bristol Britannia (G-ANBE) during its recent visit to Germany, Sweden and Denmark. After leaving London on March 18th the aircraft was demonstrated to Lufthansa at Hamburg the next day, and at Cologne on March 20th. The demonstration to S.A.S. at Stockholm on March 21st had to be cancelled owing to a suspect brake-valve, although a return visit was made to Bromma Airport following demonstrations at Copenhagen on March 22nd.

After the return to London on March 23rd Sir Alec Coryton, chairman of Bristol Aero Engines, reported: "The Swedes were particularly impressed by the lack of noise . . . but overall interest has been shown in the Britannia's short runway requirements and its general economy." Asked about the likelihood of orders, Sir Alec replied: "It is very difficult to say, but we can offer delivery to the Germans and Swedes early in 1958."

Commenting on the tour, Mr. Peter Masefield, managing director of Bristol Aircraft, said: "I think other airlines are worried what will happen when B.O.A.C. start on the North Atlantic with the Britannia, which will show up with lower fares. It may well force fares down and therefore make the American jet airliner an uneconomic aircraft before it comes in."

THE ANGLO-AMERICAN TALKS

THE discussions in London between the United Kingdom and the United States about airline route agreements (*Flight* for March 16th) were concluded with the issue of a short statement saying: "The discussions covered a number of areas including the North Atlantic, Caribbean, Far East and the Pacific. Both delegations looked forward to a period of progressive expansion of air traffic and recognized the need for adjustment of air transport to meet the demand." Approval was given for Seaboard and Western to operate cargo services into the United Kingdom (services are already operated by PanAm and T.W.A.). The Caribbean agreements, according to a statement by Mr. Harold Watkinson, Minister of Transport and Civil Aviation, gave American companies permission to operate through Jamaica from the U.S.A. to Puerto Rico; in exchange, British airlines were to have rights to operate from Caribbean centres to Houston and New Orleans. Furthermore, mutual exchange rights between the Bahamas and centres in the U.S.A. were agreed, giving British operators facilities to operate into Miami, Tampa and Fort Lauderdale. Further discussions will take place later in the year.

L.1649s FOR LUFTHANSA

AFTER a lapse of several months since the first two airlines—T.W.A. and Air France—placed orders for the Lockheed L.1649A Super Constellation, two others in recent weeks have announced their choice of this airliner. One is Linee Aeree Italiane, who have ordered four (*Flight* for March 23rd); the other is Lufthansa, who have just disclosed their decision to purchase a similar number. The German airline's new aircraft, which are to be delivered "early in 1958," will permit direct flights to be made from Frankfurt and Dusseldorf to New York in a flying time of 11 hr, and carrying full payload. Lockheed are accepting two of Lufthansa's 1049Gs in part exchange for the 1649As. The composition of Lufthansa's transatlantic fleet in 1958 will thus be six 1049Gs and two 1649As—which, say Lufthansa, will enable the airline to "remain fully competitive until we start operating jet airliners as planned for 1960." Sales of the L.1649A now account for 44 aircraft—24 for T.W.A., 12 for Air France, 4 for L.A.I., and 4 for Lufthansa.

The German airline is, incidentally, now operating transatlantic Super-G services with all-German crews; until now services have been commanded by T.W.A. captains.

Senior Bristolians boarding the Britannia for a week on the Continent (see col. 1) are, left to right, Dr. A. E. Russell, chief engineer, Bristol Aircraft; Mr. Bill Pegg, chief test pilot; Mr. Peter Masefield, managing director, Bristol Aircraft; and Sir Alec Coryton, chairman, Bristol Aero-Engines. Right, the aircraft at Bromma, Stockholm's airport, on Mar. 21st.

Delegates from the U.S.A. to the traffic talks held recently in London flew in a Viscount during a visit to Vickers-Armstrongs at Hurn. They are seen here with their Vickers hosts in front of the 100th Viscount. The London talks are recorded in an item on p. 401.

UP-TO-DATE WITH THE HERON

ONE of the most significant recent Heron deliveries was that of a demonstrator aircraft for de Havilland, Inc., of New York. This aircraft will be the first Heron with feathering airscrews to be seen in the U.S.A., and the interest it creates likely to be lively. The success of the Heron's predecessor, the Dove (more than 80 of which are in use with executive owners in the U.S.A.), is certain to favour the four-engined machine in its forthcoming demonstration tour.

A total of 106 of all Heron types has now been ordered, 93 of which have been delivered. Recent deliveries include the fourth aircraft for Braathens S.A.F.E. Airtransport of Norway, and acceptance of the first two of three aircraft ordered by Cambrian Airways is imminent. New customers include Rolls-Royce, Ltd., who have ordered an executive model, and Vestlandske Luftfarselskap, Norway, who are to have a fifteen-seat airliner version.

"I expect PanAm will order the odd 50."

AUSTRIA'S NEW AIRLINE

THE creation of a new airline, to be known as Austrian Airways, was announced in Vienna on March 23rd. The new operator is backed by the Scandinavian Airlines System, who are to own 40 per cent of the shares, and who will provide training personnel and flying crews as well as aircraft. Services will start in the summer using DC-6Bs and Convair Metropolitans on routes from Vienna to London, Rome, Zurich, Frankfurt, Copenhagen and Oslo. By the summer of 1957 the network will be extended to include Belgrade, Paris, Stockholm, Warsaw, Moscow, Budapest, Athens and Teheran. It will be recalled that another Austrian airline, Air-Austria, was recently formed with K.L.M.'s backing (*Flight*, February 10th).

CIVIL AVIATION . . .

BREVITIES

B.E.A. has reduced the return ticket from London to Paris from £12 to £10—the first of a series of cuts in night fares being made this spring by the Corporation. The £10 Paris tickets will be available for Elizabethan flights leaving London and Le Bourget simultaneously at 11 p.m. and 8 a.m.

* * *

Delegates from the governments of Denmark, Sweden and Norway are in Moscow discussing air traffic agreements with the U.S.S.R.

* * *

Mrs. Ruth Jewison, a Canadian, has been appointed district manager in the United Kingdom for Pakistan International Airlines.

* * *

A new division devoted to operational planning has been formed by American Airlines. It will be headed by Mr. Marvin J. Whitlock.

* * *

Bovingdon Aerodrome, Hertfordshire, will cease to be a civil airport as from April 1st, when its control will be transferred to the Air Ministry. It will continue to be available in emergency to civil aircraft.

* * *

Gatwick Airport was closed on April 1st to enable construction work to be started. Site clearance is well advanced, work on the road diversion has begun, and tenders for runway construction are being invited.

* * *

Capt. E. R. Watts, captain of the B.E.A. Viscount which landed safely on one engine at the French military airfield of Caseaux last January, has presented gifts to the twelve French air traffic controllers on duty at the time.

* * *

The annual diploma of the Fédération Aéronautique Internationale—the F.A.I.'s highest award—has gone to Capt. Len Inggs, South African Airways' oldest pilot, who is due to retire in September on his 60th birthday.

* * *

The Bell Aircraft Corporation are to build a 25-passenger turbine helicopter for New York Airways. The machine, to be known as the Bell D216, will have twin tip-jet rotors, and is said to be capable of reducing costs to 10 cents per seat-mile.

* * *

A B.E.A. Elizabethan *en route* from Belfast on March 27th had to take violent evasive action to avoid collision with a Vampire over Daventry. First reports stated that a number of passengers were injured as a result of being thrown about, but that both aircraft were undamaged.

Prospects of an Eland sales agency in the U.S.A. ("Flight," March 23rd) make topical this picture of the Eland - Convair, taken after dark at Napier's test centre at Luton Airport.

FASTEST · FARTHEST · HIGHEST

V *for* VICTOR

A light efficient structure gives the four-jet Victor crescent-winged bomber a very high ratio of useful load to all-up weight. From this follows its operational economy, long range and massive striking power.

HANDLEY PAGE · *RADLETT* · *LONDON* · *READING*

DUNLOP

increases safety and operational efficiency

For over twenty years Dunlop has been concerned with aircraft de-icing problems. Progress in aircraft design has demanded a new approach and a successful electro-thermal method of de-icing has been developed. It is based on the use of electrical heater circuits sandwiched between layers of rubber.

Heating of the circuits can be continuous or cyclic or a combination of both by means of a controller. Used with an ice detector, operation becomes fully automatic.

DUNLOP *DE-ICING SYSTEMS*

231

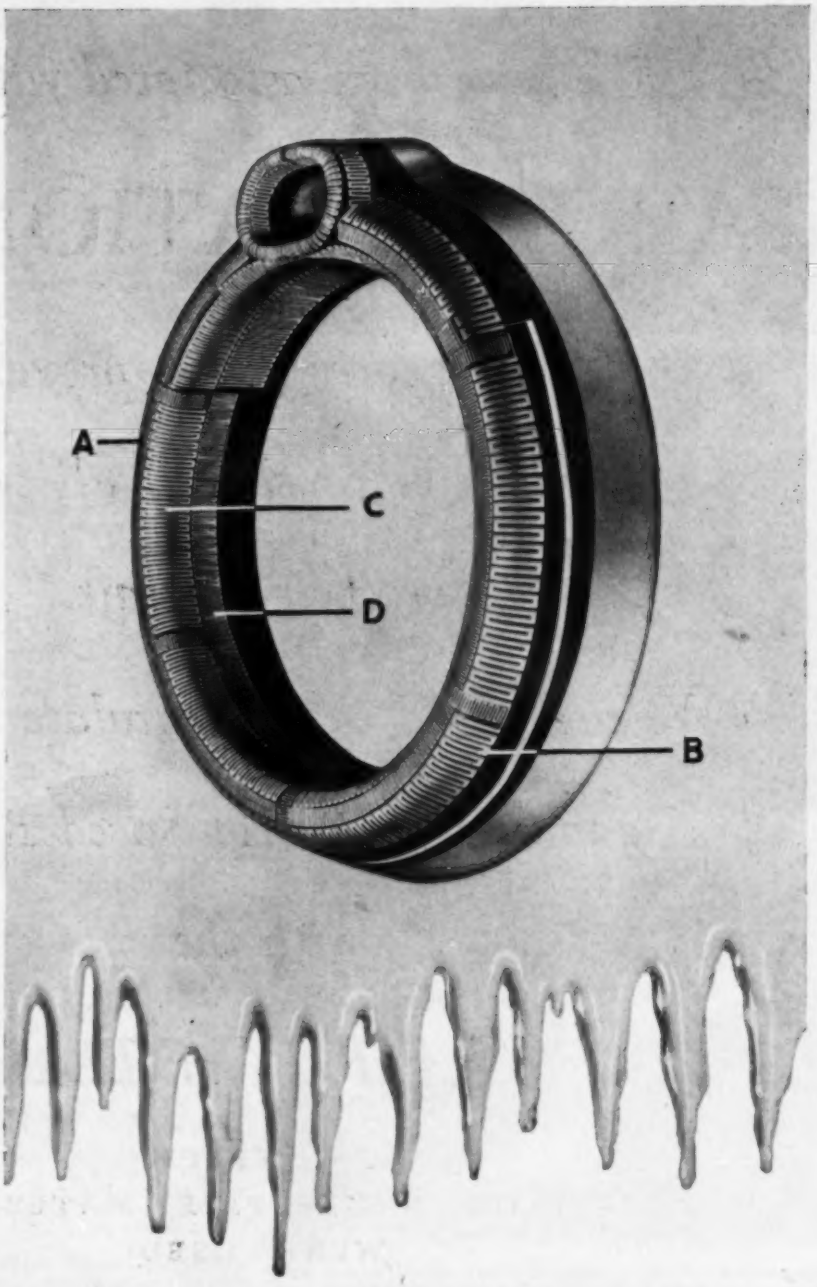
A DE-ICING SYSTEM with 3 important advantages

Dunlop thermal de-icing systems offer the following advantages:—

1. Effective removal of ice without disturbance of airflow.
2. Heat can be varied to give greatest protection at most vulnerable points.
3. Each circuit is "tailored" to suit its particular working conditions.

A further advantage is the ease with which circuits can be repaired if damaged.

The system consists of a lower layer of unvulcanised rubber which is applied directly to the metal surface of the aircraft. The heater circuit, cut or etched from nickel strip, is then placed in position and covered by a second layer of rubber. The rubber is then vulcanised to give a surface resistant to climatic conditions and the effects of fuels and hydraulic fluids.



★ A typical application of a Dunlop thermal de-icing mat to the intake duct of a Rolls-Royce 'Dart' engine. Circuit A applies continuous heat of highest intensity to the leading edge of intake. Circuits B and C are cyclic in operation and apply a lesser degree of heat to areas adjacent to the leading edge.

Circuit D again cyclically operated is situated further downstream of the intake and applies the lowest heat intensity.

MEET THE NEEDS OF THE AVIATION INDUSTRY

We have been associated with the

FAIREY AVIATION CO.

for over forty years, providing

protective finishes of all types

for their aircraft.

We are proud to congratulate them on

gaining the World Speed Record

with the

FAIREY F.D.2

ON WHICH
CELLON PROTECTIVE MATERIALS
WERE USED

CELLON

AIRCRAFT FINISHES

CELLON LIMITED · KINGSTON-ON-THAMES · PHONE: KINGSTON 1234 (9 lines)

EAST AFRICAN RALLY

Kenya Private Owners Compete

EVER since the formation of the Aero Club of East Africa in 1927 its activities have been able to capture public interest, and five thousand spectators were present at the annual rally at Nairobi West Airport on March 11th. Among them were the Deputy Governor of Kenya, Sir Frederick Crawford; Mr. I. Somen, Mayor of Nairobi; Maj.-Gen. W. D. A. Williams, Commissioner for Transport; and Mr. R. C. Catling, Commissioner for Police. No fewer than ten ex-presidents of the club were entertained by this year's president, Mr. J. R. Burgess.

The club has about 600 members, mainly in Kenya and Tanganyika, and some 25 privately-owned aircraft. The club itself owns five—two Chipmunks, two Tiger Moths and a Piper Cruiser.

On the warm and sunny Sunday afternoon of the rally, finalists from 100 entrants competed for the many silver trophies presented for the twelve events. Unexpected interest was provided by the arrival of a Canberra of No. 115 Squadron, on a "lone ranger" flight from Marham, flown by F/O. T. Shelley, with nav/bomb-aimer F/O. C. Cooke, and nav/plotter F/L. P. C. Stevens.

To everyone's great surprise and no little delight, the challenge cup donated by the *East African Standard* for the big event of the afternoon—the Aerial Derby—was carried off by Jack Trench in the 30-year-old D.H.51 *Miss Kenya* [subject of an article in *Flight* of February 3rd this year]. Eight aircraft took part, and Dr. M. H. Kirby in a Chipmunk secured second place. *Miss Kenya*, her 30-year-old engine (not quite flat out) carrying her along at 87 m.p.h., had completed the first of the three twelve-mile laps before S/L. Alec Noon took off in an Anson of Airspray (E.A.), Ltd., eventually to come in third.

The Air Wing of the Kenya Police Reserve, under the direction of their Commanding Officer, W/C. A. N. Francombe, put up a thrilling display, staging a mock Mau Mau operation, with a Cessna seeking out and marking an enemy patrol, and three Piper Pacers bombing the marker with deadly accuracy and dropping supplies to the attacking troops.

The Hooper Challenge Cup, for the best "forced" landing, was won by Ken Gould in a Chipmunk, with Miss June Wright, the only woman commercial pilot in Kenya, a close second in her Magister. Roars of laughter came from the spectators at the antics of the pilots and their passengers hurling themselves through suspended tyres on their way to and from the aircraft in the obstacle race; H. Kopperad and Miss Gunn with a Tiger Moth carried off the Roy Usher Trophy from Mr. D. Albrecht and Miss Ratzburg in a Chipmunk. In the streamer-cutting competition the Noon Cup was won by the one-handed senior ops. officer of the K.P.R., Supt. M. W. Bearcroft, in his Piper Cub. A relay race, bomb-dropping contest and many other events contributed to the interest.

Three instructors of the Aero Club wound up with a fine display of aerobatics, and, as an unexpected finale, A. Cdre. "Daddy" Probyn appeared in his home-built glider in which, the same morning, he had broken the gliding record for Kenya by staying up for 30 min at a height of about 1,500ft (above a ground level of about 5,500ft).

Trophies were presented by Mrs. Florrie Wilson—who is affectionately known as the "grandmother of aviation in East Africa," having, in 1930, founded Wilson Airways, the forerunners of the East African Airways Corporation.

Altogether, the rally provided a splendid afternoon's entertainment, thanks to the organizer, D. O. Robson, and his colleagues.

(Top) Seen at the rally: Kenya Police Reserve Piper Tri-pacer equipped for operations against Mau Mau; four 19-lb fragmentation bombs can be carried. (Centre) K.P.R. pilots: l. to r., D. Etherington, J. Bate, Supt. M. W. Bearcroft, D. C. Hellens, C. A. Pritchard, P. Harrowing. (Lower) Miss June Wright, Kenya's only woman commercial pilot, with her Magister. She was second in the landing competition.

ROYAL AERO CLUB HONOURS PHILIP WILLS

Recipients of 1954 awards of the Fédération Aéronautique Internationale were guests of honour at a Royal Aero Club dinner on Wednesday, March 21st. The guests were Mr. P. A. Wills, C.B.E., winner of the Lilienthal Medal for gliding, and three recipients of Paul Tissandier Diplomas: Mr. D. A. Gordon, Dr. S. G. Hooker, O.B.E., B.Sc., D.I.C., D.Phil., F.R.Ae.S., and Col. R. L. Preston, C.B.E., A.F.R.Ae.S. The top-table photograph shows, from the left, Mr. Gordon, hon. secretary of the Society of Model Aeronautical Engineers; Mr. S. Kenneth Davies, R.Ae.C. chairman; Mr. Wills; Lord Brabazon of Tara, R.Ae.C. president; Dr. Hooker, director and chief engineer, Bristol Aero-Engines, Ltd.; and Col. Preston, R.Ae.C. secretary-general.

SERVICE AVIATION

Royal Air Force and Fleet Air Arm News

New M.o.S. Post

THE newly formed post of Air Officer (Administration) at the Ministry of Supply has been given to A. Cdre. J. Mutch. His responsibilities will include security, inspection, maintenance and servicing policy and airfield facilities.

C.C.F. Easter Camps

DURING the Easter school holidays, between April 4th and 18th, some 3,000 members of the A.T.C. and of the R.A.F. section of the C.C.F. are attending seven-day camps at various R.A.F. stations. Two hundred of them will go to the V-bomber bases at Gaydon and Marham, but altogether 31 stations have accepted parties. Cadets are accompanied by teachers holding commissions in the R.A.F.V.R. (Training Branch).

Siamese Gift

THE sum of £300 has been given by the office of the Siamese Air Attaché in London to the R.A.F. Benevolent Fund. It marks Royal Thai Air Force Day and is in memory of Air Marshal Phya Chalerm Argas, founder of the Thai Air Force, who died last September.

The Harris Cup

LAST year's winners of the Harris Cup for marksmanship in R.A.F. Regiment units in the Middle East were No. 62 Field Sqn, based at El Adem, Libya. The formal presentation of the trophy was made recently at Nicosia, Cyprus, by A.V-M. C. D. C. Boyce, A.O.C. R.A.F. Levant. The cup was first presented by A. Cdre. J. H. Harris in 1954, when he was Senior Ground Defence Staff Officer at H.Q. M.E.A.F.

R.A.F. v. Army

WITH a score of 26 points to nine the R.A.F. beat the Army in their annual Rugby Union match at Twickenham on March 24th. Reports describing the playing of the R.A.F. team refer to its "devastating and ruthless purposefulness" and "teamwork of the highest order."

Resolute Air Base

A NEW R.C.A.F. air base is now operating all the year round at Resolute Bay, Cornwallis Island, 500 miles inside the Arctic Circle. It is about 450 miles west of Thule, the U.S.A.F. base in western Greenland, and in the centre of Canada's network of weather stations in the far northern areas. Supplies are regularly airlifted from Resolute to the stations at Mould Bay, on St. Patrick's Island and Isachsen and Ellef Ringnes Islands.

For the personnel, loneliness and the effects of extreme isolation are relieved by good quarters, organized recreation, regular mail and radio services.

Mr. Massey, Governor - General of Canada, was recently flown over the North Pole from Resolute in a R.C.A.F. North Star transport. Over the Pole he dropped a special container (see photograph on this page) through the flare chute. It held his personal standard and a letter asking the finder of the capsule to take it to the nearest authorities. On the outside, a copper plaque inscribed in English, French and Danish asked the finder to open the container. It descended to the ice by parachute. The return flight from Resolute to the North Pole took 10 hours.

The special container made by No. 412 Transport Sqn, R.C.A.F., and dropped at the North Pole by the Rt. Hon. Vincent Massey, Governor-General of Canada. (See "Resolute Air Base.")

W.R.A.F. Appointments

THE appointment of G/Off. J. L. A. Conan-Doyle to command R.A.F. Hawkinge, Kent, has been announced by the Air Ministry. G/Off. Conan-Doyle has been Inspector of the W.R.A.F. since 1954, and she will be succeeded in this post by W/Off. F. B. Hill, who will assume the acting rank of group officer. W/Off. Hill has most recently been W.R.A.F. Staff Officer at H.Q. Home Command.

Exercise "Dawn Breeze"

THE closing stages of the NATO air/sea exercise "Dawn Breeze" included an air attack launched against Southern England by aircraft operating from the British carriers *Ark Royal* and *Bulwark* lying off Brittany. Defending forces included R.A.F. fighters, R.N. and R.N.V.R. squadrons, and Meteors and Vampires of the R.Aux.A.F. deployed at bases in the West.

In earlier phases of the exercise weather had caused considerable curtailment of plans, but during this final air attack on England jet aircraft were operated from carriers when no diversions were available.

While the crew of *Ark Royal* were preparing for Easter leave as the carrier was returning to England, a Gannet showed that there was no weapon it could not throw at an enemy. It flew alongside the carrier dispensing a series of buoys and flares and finally dropped a large white kitchen sink on a parachute. The sink—which sank—had been salvaged from a scrap yard in Gibraltar.

R.A.A.F. Aviation Medicine

A NEW school of aviation medicine for the R.A.A.F. is being established at Point Cook, Victoria, and will be commanded by W/Cdr. W. L. Rait. The school is the first of its kind in the Southern Hemisphere and will train Service doctors to deal with the effects of modern flying conditions on aircrew.

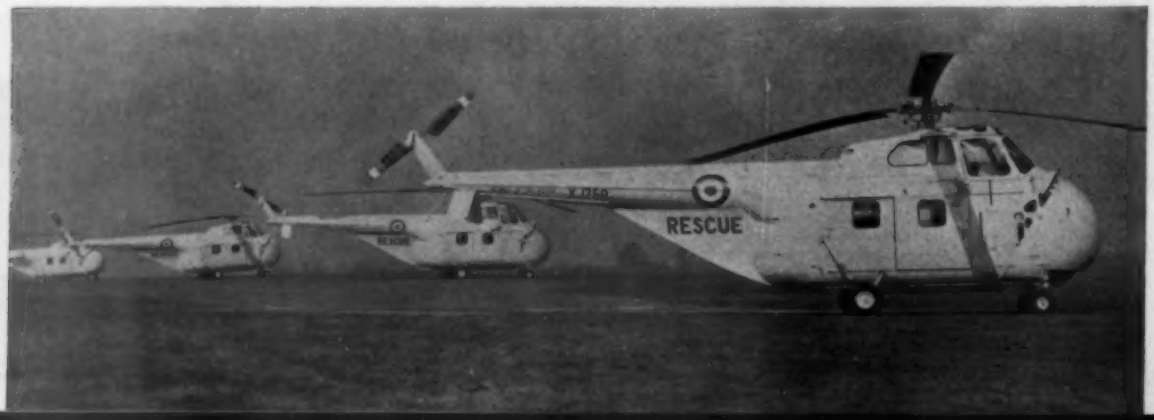
Getting Tankers Through

ENGLISH, Australian and New Zealand ships and aircraft near Malaya have taken part in a sea/air exercise designed to practise the task of getting tanker convoys through to Singapore.

Reunion Postponed

THE R.F.C. and R.N.A.S. Reunion, Portsmouth, which was originally planned for today, April 6th, has had to be postponed until May 25th. It will take place in the Officers' Mess, 457 H.A.A. Regt., R.A., St. Paul's Road, Portsmouth. Details from E. F. Redman, Lloyd's Bank, Ltd., Commercial Road, Portsmouth.

Four brand-new Westland Whirlwinds await delivery from Yeovil to Coastal Command rescue squadrons. The R.A.F. has standardized this machine for such duties. R.N. and R.A.F. helicopters saved 70 Service and civilian lives during the first two months of this year.



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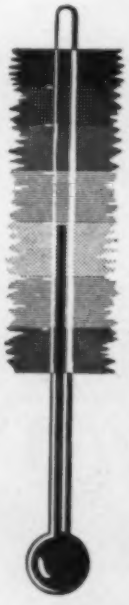

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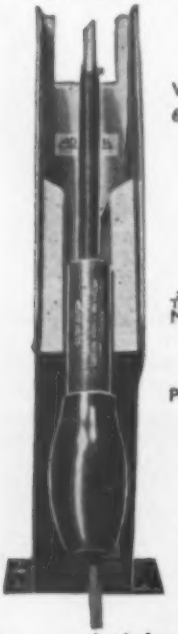

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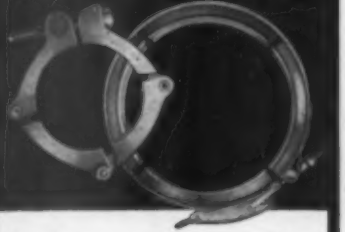

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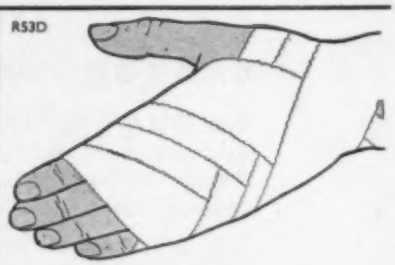

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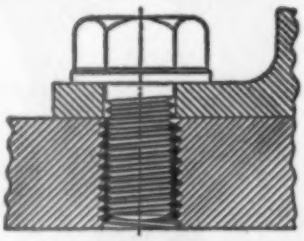

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PATENTS

THE proprietors of British Patent No. 663,152 for "Jettisonable Closure or Hood for the Cockpits of Aircraft," desire to enter into negotiations with a firm or firms for the sale of the patent, or for the grant of licences thereunder. Further particulars may be obtained from Marks and Clerk, 57 and 58, Lincoln's Inn Fields, London, W.C.2. [5061

PUBLIC ANNOUNCEMENTS

AIR TRANSPORT ADVISORY COUNCIL

THE Air Transport Advisory Council give notice that they have received the undermentioned applications to operate scheduled air services:—

FROM Manx Airlines, Ltd., of Ronaldsway Airport, Isle of Man:—

APPLICATION No. 758. For a U.K. Internal Service with Bristol 170 and Dakota aircraft for the carriage of passengers and supplementary freight between Isle of Man (Ronaldsway) and Stranraer (Castle Kennedy) at a frequency of from one to three return flights daily increasing further according to traffic demand for a period of 10 years, from date of approval.

APPLICATION No. 759. For a U.K. Internal Service with Bristol 170 and Dakota aircraft for the carriage of passengers and supplementary freight between Isle of Man (Ronaldsway) and Belfast (Newtownards) at a frequency of from one to three flights daily increasing further according to traffic demand for a period of 10 years, from date of approval.

FROM Eagle Aviation, Ltd., of 29, Clarges Street, London, W.1, for the following Seasonal Inclusive Tour Services in conjunction with Sir Henry Lunn, Ltd., for the carriage of passengers and supplementary freight at a frequency of seven return flights weekly on each service during the season from April to October inclusive for a period of seven years commencing 1st April, 1957:—

APPLICATION No. 760 for a service between London (Blackbushe) and Nice (Le Var) with Viking and/or Dakota aircraft.

APPLICATION No. 761 for a service between London (Blackbushe) and Biarritz (for San Sebastian), with Viking and/or Dakota aircraft.

APPLICATION No. 764 for a service between London (Blackbushe) and Barcelona with Viking aircraft.

FROM Silver City Airways, Ltd., of 1, Great Cumberland Place, London, W.1.

APPLICATION No. 762. For a Vehicle Ferry Service with Bristol 170 aircraft for the carriage of vehicles, passengers and supplementary freight between Isle of Man (Ronaldsway) and Belfast (Newtownards) at a frequency of from one to 12 return flights daily for a period of 10 years, from date of approval.

APPLICATION No. 763. For a Vehicle Ferry Service with Bristol 170 aircraft for the carriage of vehicles, passengers and supplementary freight between Isle of Man (Ronaldsway) and Stranraer (Castle Kennedy) at a frequency of from one to 12 return flights daily for a period of 10 years, from date of approval.

FROM Eagle Aviation, Ltd., of 29, Clarges Street, London, W.1:—

APPLICATION No. 765. For a Normal Scheduled Service with Viking and/or Dakota aircraft and later possibly with Viscount aircraft for the carriage of passengers, supplementary freight and mail between Manchester (Ringway) and Brussels and/or Frankfurt at an initial frequency of from one to seven return flights daily for a period of 10 years, from date of approval.

APPLICATION No. 766. For a Normal Scheduled Service with Viking and/or Dakota aircraft and later possibly with Viscount aircraft for the carriage of passengers, supplementary freight and mail between Manchester (Ringway) and Hamburg and/or Copenhagen (Kastrup) at an initial frequency of from one to seven return flights weekly for a period of 10 years, from date of approval.

THESE applications will be considered by the Council under the Terms of Reference issued to them by the Minister of Civil Aviation on 30th July, 1952. Any representations or objections with regard to these applications must be made in writing stating the reasons and must reach the Council within 14 days of the date of this advertisement, addressed to the Secretary, Air Transport Advisory Council, 3, Dean's Yard, London, S.W.1, from whom further details of the applications may be obtained. When an objection is made to an application by another air transport company on the grounds that they are applying to operate the route or part of route in question, their application, if not already submitted to the Council, should reach them within the period allowed for the making of representations or objections. [5055

PUBLIC APPOINTMENTS

ENGINEER or Physicist required by Min. of Supply H.Q., London, to assist in technical administration, including liaison with industry, on research and development of automatic pilots and similar equipment for R.A.F. and Fleet Air Arm. Qualifications: H.S.C. (Science) or equivalent, but pass degree or H.N.C. may be an advantage. Experience with aircraft equipment or light electro-mechanical engineering or instruments desirable. Salary within scale, Experimental Officer (min. age 26), £790-£960. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A112/6A/BY. [5048

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PUBLIC NOTICES

THE COLLEGE OF AERONAUTICS

The Board of Entry of the College invites applications from suitable candidates for the two-year course which begins in October, 1956 and ends in June, 1958.

Candidates should be of graduate standard although the possession of a degree is not essential; a good Higher National Certificate is an acceptable standard.

The College, a post graduate institution, is devoted to the study of aeronautical science and engineering. The curriculum covers the five main subjects of Aerodynamics, Aircraft Design, Aircraft Electrical Engineering, Aircraft Propulsion and Aircraft Economics and Production. Instruction in the first year is designed to provide all students with a broad background of knowledge in all these subjects, with opportunity for limited specialisation in two or three of them. In the second year, students specialise more particularly, usually in one subject.

Experiments in the air are an important part of the work, both in the first year when all students take part in them and in the second year when they are linked to the specialist work of the departments.

Students who satisfactorily complete the course will receive the Diploma of the College.

Further particulars and details of the procedure for enrolment may be obtained from:

The Warden,
The College of Aeronautics,
Cranfield,
Bletchley,
Bucks. [4926

THE COLLEGE OF AERONAUTICS

Applications are invited for the Perring Scholarship in Aeronautics, valued £400 per annum, tenable at The College of Aeronautics. The successful candidate will be admitted to the two-year course at the College.

Applicants should preferably be honours graduates or final year undergraduates in engineering, mathematics or physics; applications from non-graduates with comparable qualifications will also be considered. Candidates must be British subjects domiciled in the United Kingdom.

Forms of application and statement of conditions will be forwarded on written application to:

The Warden,
The College of Aeronautics,
Cranfield,
Bletchley,
Bucks.

THE closing date for the receipt of applications is 18th May, 1956. [4924

THE COLLEGE OF AERONAUTICS

ENGLISH ELECTRIC RESEARCH FELLOWSHIP IN AERONAUTICS

Applications are invited for a Research Fellowship which has been established at the College by the English Electric Co., Ltd. The Fellowship is intended to provide opportunity for post-graduate research into problems of vibration or stability and control of aircraft, and is tenable for one year beginning on or about 1st October, 1956. The value of the Fellowship is £500.

Applications, giving full particulars of education and experience and quoting the names of three referees, are required by 1st May, 1956, and should be addressed to:

The Warden,
The College of Aeronautics,
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HOUSING assistance will be given if required.

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SENIOR design draughtsmen, men with considerable experience in the aircraft industry, are offered the opportunity of joining an organisation engaged on work of great interest and importance.

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AIRLINE Pilot required. Minimum requirements commercial licence and instrument rating for Rapide and Dove aircraft. Apply Channel Airways, Southend Airport. [5026

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KING AIRCRAFT CORPORATION require Senior, Intermediate and Junior Draughtsmen, and Stress Engineers, at their Central Glasgow Design Offices for work on an expanding programme of interesting and important projects of an advanced nature. Good salaries and conditions. Forward details of previous experience to:—Personnel Officer, King Aircraft Corporation, Hillington, Glasgow, S.W.2. [0422

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GRADUATES in Science or Engineering for development work on gas turbine fuel systems for aircraft and commercial projects. Training will be given if required to personnel newly qualified. These vacancies are pensionable and offer opportunities for individuals to progress to senior appointments in a new and rapidly expanding company. Applications should be made to the Personnel Manager, Joseph Lucas (Gas Turbine Equipment), Ltd., Shaftmoor Lane, Hall Green, Birmingham, 28. [5034

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SITUATIONS VACANT

SCOTTISH AVIATION have immediate vacancies for aircraft stressmen and aerodynamicists for work on the Prestwick Twin Pioneer aircraft. Excellent prospects for experienced men. New houses are also immediately available. Applicants should reply in writing giving details of experience and training to the Personnel Manager, Scottish Aviation, Limited, Prestwick Airport, Ayrshire. [4911]

SCOTTISH AVIATION urgently require Planning Engineers for work on their Prestwick Twin Pioneer project. Applicants should have served a recognised Engineering Apprenticeship and have previous Aircraft Planning experience. Houses immediately available. Reply giving details of training and experience to Personnel Manager, Scottish Aviation, Ltd., Prestwick Airport, Ayrshire. [4858

STRESSMEN in all grades required. Salaries range from £500 p.a. to £1,100 p.a. Qualifications required: H.N.C., Certificate of Education (Advanced Level), B.Sc. Engineering, Mathematics or Physics. Previous experience not essential but will be taken into account when fixing salary. Application forms from Chief Stressman, Electro-Hydraulics Limited, Liverpool Road, Warrington, Lancs. [4956

SENIOR qualified development engineers and technicians required in research department of a well-known firm of precision engineers, particularly for work in connection with Servo systems, small precision motors and gyroscopic control systems. Apply stating age, qualifications, experience, and salary required to S. G. Brown, Ltd., Shakespeare Street, Watford, Herts. [0146

ARMSTRONG SIDDELEY MOTORS have a vacancy for an Honours Degree Mathematician in an expanding section, using electronic calculating machines for the solution of all types of problems associated with the development of gas turbine aero engines. Experience is not necessary but would be taken into account in fixing the initial salary. Applications with full details should be submitted to Reference DRE, Technical Personnel Officer, Armstrong Siddeley Motors, Coventry. [0460

ARMSTRONG Siddeley Motors has a vacancy for a flight test observer in connection with flight testing gas turbine engines. Applicants should have a Degree or equivalent in either Mech. or Aeronautical Engineering. Previous flying experience not necessary. Selected applicants will be required to undergo a medical examination. Good salary offered dependent on age, experience and qualifications. Applications to Reference FL/T, Armstrong Siddeley Motors, Coventry. [0472

HANDLEY PAGE (READING), LIMITED, The Aerodrome, Woodley, Reading, Berks, have vacancies for Senior Stressmen for interesting work on Civil Aircraft. High commencing salaries will be paid and new houses to rent will be offered to successful applicants. Also required are Senior and Intermediate Design Draughtsmen and Weights Engineers. Superannuation and Life Assurance Scheme is in operation for all staff employees. Please send full particulars of experience, etc., to the Personnel Officer. [0280

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ARMSTRONG SIDDELEY MOTORS, Coventry, require an Assistant Technical Engineer for project work. This is a unique opportunity for a young man with some technical qualifications to enter the most interesting side of the gas turbine field. The position gives full scope for technical ability, entailing investigations and design calculations on many advanced and challenging projects. Applications with full details of age, qualifications and experience, if any, to the Technical Personnel Manager, Armstrong Siddeley Motors, Coventry, quoting 'Projects 1.' [0464

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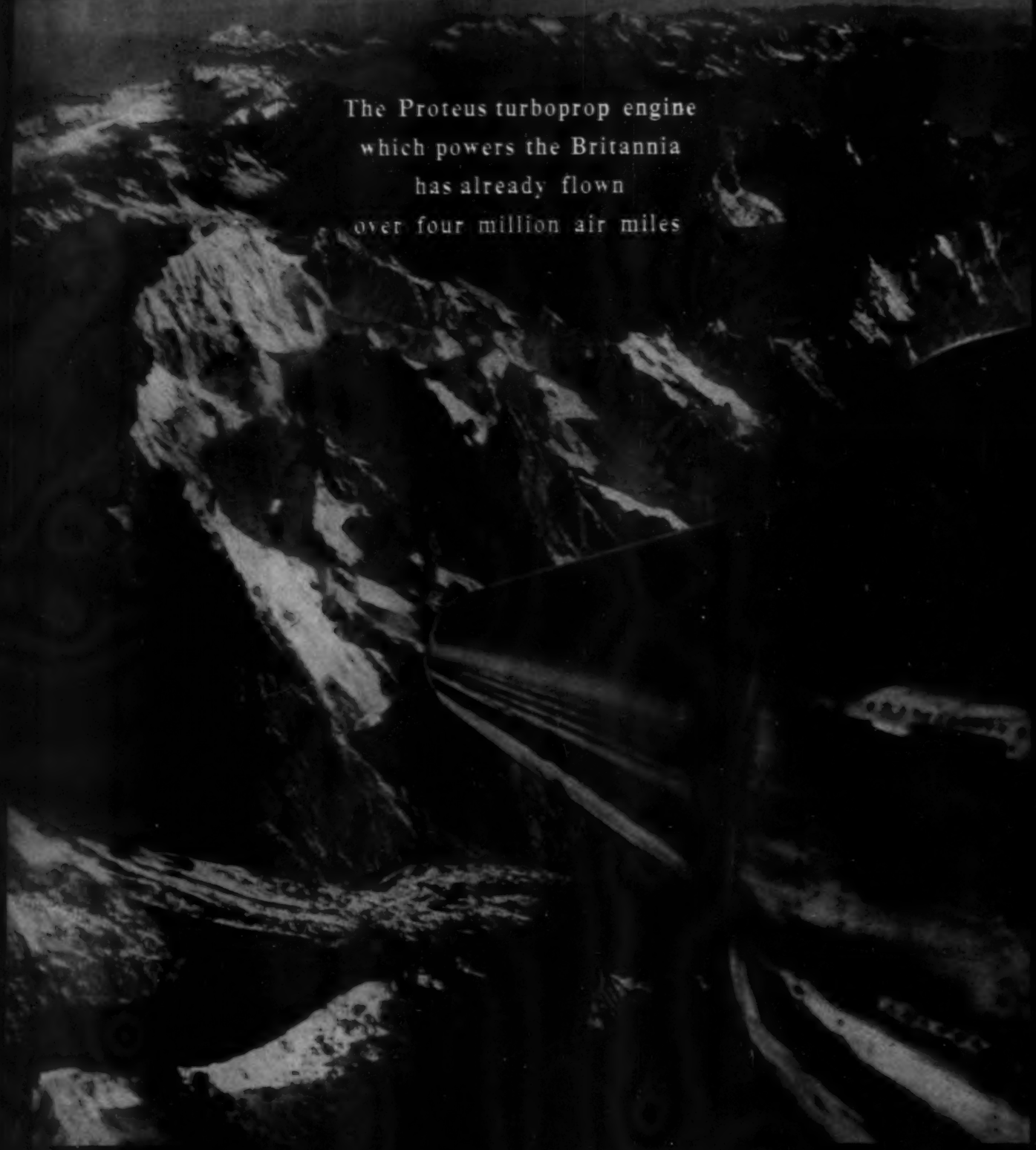

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